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A. C. TRUE, Director.

EXPERIMENTS

ON THE

Metabolism of Matter and Energy in the Human Body,

1898-1900.

BY

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WITH THE COOPERATION OF

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., December 15, 1901.

SIR: I have the honor to transmit herewith a general report of 13 experiments on the metabolism of matter and energy in the human body, by W. O. Atwater, special agent in charge of nutrition investigations, and F. G. Benedict, expert in these investigations, with the cooperation of A. P. Bryant, A. W. Smith, and J. F. Snell. Valuable aid was also rendered by Messrs. P. B. Hawk, H. M. Burr, E. Osterberg, and others. In addition to the details of these 13 experiments on the general subject of the metabolism of matter and energy a considerable number of general deductions are drawn from the experiments as a whole.

These experiments form part of a series which is in progress at Middletown, Conn., in cooperation with the Storrs Agricultural Experiment Station and Wesleyan University. They were made with the Atwater-Rosa respiration calorimeter. The apparatus and the earlier experiments have been described in previous bulletins of this Office (Nos. 44, 63, and 69). Such experiments as those reported have for their ultimate object the study of the fundamental laws of nutrition. The results obtained are of such a nature as to warrant the conclusion that the respiration calorimeter is a satisfactory instrument of precision. The experiments here described, like those previously reported, yield important data regarding the transformation and the conservation of energy in the body, the demands of the body for nutriment, the effects of muscular work upon that demand, and the nutritive values of different nutrients and different foods.

The report is submitted with the recommendation that it be published as Bulletin No. 109 of this Office.

Respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

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METABOLISM OF MATTER AND ENERGY IN THE HUMAN BODY.

INTRODUCTION.

The present report gives the details of 13 experiments upon the metabolism of matter and energy in the human body, made at Middletown, Conn., under the auspices of the U. S. Department of Agriculture, in cooperation with the Storrs Experiment Station and Wesleyan University. These experiments, which are in continuation of those reported in earlier bulletins of this series,[a] were carried on during the years 1898 to 1900, with the same respiration calorimeter[b] and by the same methods. In addition to the experiments reported in the present bulletin, 11 other experiments, which for convenience of reference have been numbered consecutively with these, were made with the same apparatus at Wesleyan University, during the same years, in connection with an independent investigation, and are reported elsewhere.[c]

QUESTIONS STUDIED.

As has already been explained, the ultimate purpose of experiments with men in the respiration calorimeter is the study of some of the fundamental laws of nutrition, and the whole inquiry is based upon the principle that the chemical and physical changes which take place within the body, and to which the general term "metabolism" is applied, occur in obedience to the laws of the conservation of matter and of energy.

No one doubts that the law of the conservation of matter governs its metabolism in the living organism, and it is generally believed that the law of the conservation of energy likewise applies to the metabolism of energy. Quantitative determinations of the applications of this law are, however, desirable.

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[a] U. S. Dept. Agr., Office of Experiment Stations Buls. 44, 63, and 69.

[b] U. S. Dept. Agr., Office of Experiment Stations Buls. 44 and 63. See also Conn. (Storrs) Sta. Rpt. 1897, p. 212, and Physical Review, 9 (1899), pp. 130–163, 214–251.

[c] Memoirs of the National Academy of Sciences, Vol. VIII, Sixth Memoir, 1902.

The main subjects proposed for study have been the following:

(1) The application of the law of the conservation of energy in the body. An experimental demonstration of the action of this law was the first object sought. The fundamental principle once proven, the apparatus and methods can be utilized for the study of some of the fundamental problems of the science of food and nutrition.

(2) The quantities of nutrients and energy metabolized by men under different conditions of rest and muscular and mental exercise.

(3) The amounts of nutrients and energy required for internal physiological work, as that of respiration, circulation, and digestion.

(4) The relation between external muscular work and the nutrients and energy metabolized in its performance. This general problem includes the narrower one of the power of the body as a machine to convert the potential energy of its food and of its previously stored material into muscular energy. Viewed from one standpoint this latter phase of the subject is the same as that to which the expression "the animal body as a prime motor" is frequently applied. From another standpoint it includes the comparison of the animal body with steam engines and other sources of power in respect to the economy with which the energy of fuel is utilized, the fuel in the case of the animal being its food, while in the case of the ordinary machine it is coal, oil, gas, or wood.

(5) The transformations of nutrients and energy in mental work.

(6) The capacities of the different classes of nutrients to supply the body with material and energy, the proportions in which they may replace one another in building tissue or yielding energy as heat or as muscular work, and their power to protect one another and the materials of the body from consumption.

(7) The nutritive values of food materials and the fitting of food to the needs of the consumer.

Of the above problems all have received considerable attention except No. 5, which has to do with food and mental work. This has as yet been made the especial subject of only one experiment. It is hoped that the study of this problem may also be entered upon in the not too distant future. Besides the problems thus detailed a number of others have received attention. Among these are:

(8) The digestion and assimilation of food materials.

(9) The quantities of carbon dioxid, water, nitrogen, and other materials excreted by the body as well as the energy given off as heat and as external muscular work under different conditions of work and rest, together with the rates of elimination at different periods of the day and night. In this connection the respiratory quotient has also been considered.

(10) The temperature of the body and its variation during different periods of the day and under different conditions of work, rest, and sleep.

(11) The need of ventilation in so far as the comfort of the person under experiment is affected by the proportions of carbon dioxid, and water in the air in the respiration chamber.

(12) Finally, a large amount of time, thought, and labor has been devoted to the elaboration and testing of the apparatus and methods of experimenting. Five years were thus used before the first actual experiments with men were made, and more or less attention is being constantly given to the same subject.

GENERAL PLAN OF THE APPARATUS AND THE EXPERIMENTS.

The description of the apparatus and the methods of manipulation of the experiments have been given with sufficient detail in the former publications already referred to. It is sufficient to say in this connection that the essential features of the apparatus are a chamber large enough to permit a man to stand up and lie down at full length; appliances for measuring and analyzing a ventilating current of air; arrangements for passing food and drink into the chamber and removing the solid and liquid excreta, all of which were carefully weighed and sampled for analysis; and devices for determining the heat given off from the body of the man in the chamber, and, in work experiments, for determining the heat equivalent of the muscular work done. Measurements were made of income and outgo of both matter and energy in the man's body during the period of the experiment. The chemical analyses included determinations of the total quantities of the nitrogen, carbon, hydrogen, water, and mineral matter of food, drink, and respiratory and excretory products. In obtaining the income and outgo of energy, the potential energy of the food eaten and of the solid and liquid excreta was determined by means of the bomb calorimeter, and the kinetic energy given off by the subject was measured by the respiration calorimeter and accessory apparatus.

TEST EXPERIMENTS.

Before the respiration calorimeter can be used in such experimenting, its accuracy, both as a respiration apparatus and as a calorimeter, should be demonstrated. Two methods have been adopted for testing its accuracy; first, by generating known amounts of heat electrically, and, second, by burning known amounts of pure ethyl alcohol within the respiration chamber and measuring the heat and the chemical products of combustion. The mean of five electrical tests of the apparatus, made previous to the experiments here reported, showed a variation between the heat actually measured and that generated so small as to be far within the limits of experimental error. The mean of nine experiments, in which known amounts of ethyl alcohol were burned within the chamber of the calorimeter and the carbon dioxid, water,

and heat given off were determined, showed variations between the observed and the theoretical amounts no greater than are ordinarily obtained by the usual analytical methods employed in the laboratory. The detailed description of the electrical and alcohol test experiments may be found in earlier bulletins of this series.[a]

Without going further into the details of the experiments it will suffice to say that they were conducted in the same way as the similar test experiments previously reported, by burning within the calorimeter a known amount of ethyl alcohol in a specially arranged lamp and determining the amounts of carbon dioxid, water, and heat given off. The air current which passed through the chamber and the conditions of the experiment were very similar to those when a man was confined within the apparatus.

As stated above, the electrical tests were all made previous to the time of the experiments here reported. Of the other test experiments, the details of which have already been published, one, No. 9, was made in the late spring of 1898, at the close of the second of the metabolism experiments here described. During the summer of 1898 no experiments were carried on with the respiration calorimeter. The first test experiment of the fall commenced November 3, 1898. The agreements between the determined and theoretical amounts of carbon dioxid, water, and heat, while not as close as had sometimes been found, were probably within the limits of experimental error, thus indicating that the apparatus was in good working condition. Following this test came metabolism experiment No. 13, reported in this bulletin, which was immediately followed by another test experiment, No. 11.

About the middle of December, 1898, still another test experiment, No. 12, gave results which indicated that the apparatus was in satisfactory condition, although the measurement of water was not as close as might be desired. This test was followed by metabolism experiment No. 14, the details of which are given further on. The calorimeter was then used for some experiments not reported in this bulletin. At their close test No. 13 was made, which again showed the apparatus to be in satisfactory condition, although the water determined was in excess of the theoretical. Metabolism experiments Nos. 23 and 24 followed the completion of test No. 13, and one week after their completion test No. 14 was made. In this latter test, while the results of the determinations of carbon dioxid and water given off in the apparatus agreed very closely with the theoretical, it was found that the heat measured by the calorimeter was 3.2 per cent less than the heat theoretically given off by the combustion of the alcohol. Test experiment No. 15, made in December, 1899, showed similar agreements of carbon dioxid and water, and disagreement of heat. It was also found

[a] U. S. Dept. Agr., Office of Experiment Stations Buls. 63, pp. 38–74; 69, pp. 8–17.

by thermal[a] tests and electrical tests that the measurement of heat by the apparatus was not correct. An electrical test made in the early part of December, 1899, showed a loss of over 3 per cent of the heat put into the apparatus. A thermal test made at this time showed that there was trouble with the thermo-electric elements.[b] The difficulty apparently lay in a slight short circuit of these at some point, which interfered with the accuracy of the measurements.

Just when the short circuiting occurred it is impossible to say. The test experiment preceding metabolism experiments Nos. 23 and 24 showed the apparatus to be in a satisfactory condition. Test experiments made shortly after the close of these experiments showed a discrepancy in the heat measured as compared with that theoretically given off. There is nothing to indicate whether the trouble occurred before, during, or at the close of this series of metabolism experiments or in the short interval immediately following. The agreement of the theoretical energy of the material oxidized in the body and that measured by the calorimeter in metabolism experiments Nos. 23 and 24 would seem to indicate that the trouble did not occur until the close of the series. Had it occurred before or during these experiments the heat as actually determined by the apparatus would doubtless have been about 3 per cent smaller than the amount which would have been measured had the apparatus been in its usual condition. This would make the heat measured by the calorimeter much smaller in amount than the theoretical heat given off by the oxidation of material in the body of the subject, the deficiency being larger than has been found in previous experiments.

Since it is impossible to determine just when the trouble arose, the details of experiments Nos. 23 and 24 are here given with the values actually obtained, and the supposition is made that the trouble in the apparatus occurred after the close of the experiments. The data are, however, given by which any correction which seems fitting can be applied. After test experiment No. 15, some repairs were made in the apparatus, following which came test experiment No. 16, in which ethyl alcohol was burned in the respiration chamber. In this test the results obtained were very near the theoretical values for carbon dioxid and heat, but nearly 4 per cent more water was found than should have been obtained from the quantity of ethyl alcohol burned. It was thought best, however, not to delay further the metabolism experiments of 1899–1900, therefore no other test experiments were made until April, 1900, at the close of metabolism experiment No. 34. At this time test experiment No. 17 gave results very similar to those obtained in the previous test experiment, and indicated that the measurements of water in the test experiments were

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 69, p. 15.

[b] U. S. Dept. Agr., Office of Experiment Stations Bul. 63, p. 17.

over 4 per cent too large. This excess of water may have been due to either or all of several causes. There may have been a small leak whereby air from the room was drawn into the ventilating air current at some point beyond the "freezer"[a] for the incoming air; but careful examination failed to reveal any noticeable leak inside the chamber, though later experiments implied that there may have been a leak in the "valve box," through which the air passed on its way from the chamber to the meter pump. It is possible that some of the moisture condensed on the outside of the valve box may have found its way into the air current. This would increase the amount of water found by analysis of the outgoing air, but would not materially affect the determination of either carbon dioxid or heat. There may have been evaporation of water which had condensed on the absorbers and walls of the chamber before the test began; however, there could not have been sufficient water present to account for all of the excess.

Taking everything into consideration we do not feel warranted in assuming any definite error in the determination of water in metabolism experiments Nos. 25–34. Such error, if it existed, would not affect the nitrogen and carbon balance at all and would hardly affect the heat balance appreciably. From the figures for test experiments Nos. 16 and 17 it will be observed that the excess of water found over the theoretical amounted to not far from 1 gram per hour. If we assume in experiments Nos. 25–34 a leak in the air current sufficient to account for about 1 gram of water per hour or 24 grams per day, the values given in column *e* of Tables 91, 106, 122, and 138 would be too large by a corresponding amount, and the figures in columns *f* and *g* of these same tables would be 14 calories too large. This amount would make a maximum error of 0.5 per cent in the heat in the rest experiments (Nos. 25, 26, and 28) and about 0.3 per cent in the work experiments (Nos. 29, 31, 32, and 34).

The results of test experiments Nos. 1–9 have already been published.[b] The results of tests Nos. 10–17 are summarized in Table 1, together with the mean results of tests Nos. 1–9. The proportion of absolute ethyl alcohol (by weight) in the commercial alcohol burned in the lamp in the different test experiments was as follows: Test No. 10, 91.03 per cent; tests Nos. 11–14, 90.85 per cent; and tests Nos. 15–17, 90.57 per cent.

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[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 63, p. 30.

[b] U. S. Dept. Agr., Office of Experiment Stations Buls. 63, p. 50; 69, p. 13.

TABLE 1.—*Summary of test experiments in which ethyl alcohol was burned in the respiration chamber.*

No.	Date.	Duration.	Alcohol burned in lamp.	Carbon dioxid.		
				Required.	Found.	Ratio of amount found to amount required.
		h. m.	*Grams.*	*Grams.*	*Grams.*	*Per cent.*
10	November 3 to 4, 1898	35 44	666.7	1,159.8	1,163.9	100.3
11	November 15 to 16, 1898	35 00	751.2	1,304.2	1,293.7	99.2
12	December 13 to 14, 1898	27 56	619.4	1,075.4	1,067.7	99.3
13	February 24 to 25, 1899	24 00	545.7	947.8	943.9	99.6
14	March 29 to 31, 1899	52 40	1,001.6	1,738.9	1,744.6	100.3
15	December 13 to 14, 1899	37 40	825.4	1,428.6	1,424.9	99.7
16	December 19 to 21, 1899	26 12	438.7	759.3	753.2	99.2
17	April 6 to 7, 1900	29 59	539.2	933.3	928.8	99.5
	Total of tests 10 to 17	269 11	.....	9,347.3	9,320.7	99.7
	Total of tests 1 to 9[a]	317 20	.....	9,892.5	9,886.2	99.9
	Total of tests 1 to 17	586 31	.....	19,239.8	19,206.9	99.8

No.	Date.	Duration.	Alcohol burned in lamp.	Water.		
				Required.	Found.	Ratio of amount found to amount required.
		h. m.	*Grams.*	*Grams.*	*Grams.*	*Per cent.*
10	November 3 to 4, 1898	35 44	666.7	772.5	773.5	100.1
11	November 15 to 16, 1898	35 00	751.2	869.8	878.2	101.0
12	December 13 to 14, 1898	27 56	619.4	717.2	705.7	98.4
13	February 24 to 25, 1899	24 00	545.7	631.9	643.4	101.8
14	March 29 to 31, 1899	52 40	1,001.6	1,159.7	1,187.0	102.4
15	December 13 to 14, 1899	37 40	825.4	955.1	945.9	99.0
16	December 19 to 21, 1899	26 12	438.7	507.6	527.7	103.8
17	April 6 to 7, 1900	29 59	539.2	623.8	653.9	104.8
	Total of tests 10 to 17	269 11	.....	6,237.6	6,315.3	101.2
	Total of tests 1 to 9[a]	317 20	.....	6,026.8	6,063.8	100.6
	Total of tests 1 to 17	586 31	.....	12,264.4	12,379.1	100.9

No.	Date.	Duration.	Alcohol burned in lamp.	Heat.		
				Required.	Found.	Ratio of amount found to amount required.
		h. m.	*Grams.*	*Calories.*	*Calories.*	*Per cent.*
10	November 3 to 4, 1898	34 44	666.7	4,289.4	4,269.1	99.5
11	November 15 to 16, 1898	35 00	751.2	4,822.6	4,844.4	100.5
12	December 13 to 14, 1898	27 56	619.4	3,976.9	3,960.1	99.6
13	February 24 to 25, 1899	24 00	545.7	3,503.6	3,497.9	99.8
14	March 29 to 31, 1899	52 40	1,001.6	[6,430.7]	[6,222.8]	96.7
15	December 13 to 14, 1899	37 40	825.4	[5,283.0]	[5,145.3]	97.5
16	December 19 to 21, 1899	26 12	438.7	2,807.9	2,801.6	99.7
17	April 6 to 7, 1900	29 59	539.2	3,450.9	3,464.8	100.3
	Total of tests 10 to 17[b]	269 11	.....	22,851.3	22,837.9	99.9
	Total of tests 1 to 9[a]	317 20	.....	41,702.8	41,675.4	99.9
	Total of tests 1 to 17	586 31	.....	64,554.1	64,513.3	99.9

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 69, pp. 13–14.

[b] Omitting the determinations of heat in Nos. 14 and 15.

The table shows the duration of the tests, the amount of ethyl alcohol burned in the lamp, and the theoretical amount of carbon dioxid, water, and heat which would have been produced by the combustion of the alcohol as compared with the amounts actually found. As previously noted, the agreement between theoretical values and those actually obtained is, as a rule, very close.

SAMPLING OF THE AIR CURRENT FOR ANALYSIS.

Two methods have been employed for sampling the outgoing current of air for analysis. After this current of air has left the cooling apparatus where the major portion of the water has been condensed, small samples of about 150 liters each during every six-hour period are drawn by the aspirators. The details of this method and the formulas used for calculating and correcting the results are given in a previous publication.[a]

The greatest objections to the use of the aspirators as a method of sampling the air are: (1) The number of corrections for temperature, barometric pressure, and tension of aqueous vapor which have to be made in finding the actual volume of air drawn into the aspirators; (2) the variations in the speed of the motor driving the meter pump and, consequently, in the volume of the ventilating air current, these not being accompanied by corresponding variations in withdrawal of the sample, and (3) the irregularity with which the sample is drawn. By means of an automatic device for regulating the speed at which the water runs out from the aspirators it has been possible of late to make this rate very uniform. At the same time relatively small fluctuations might introduce errors. Thus, if the aspirators emptied more slowly than the normal at a period when the man was giving off more than the average amount of carbon dioxid, as, for instance, when he was weighing the "absorbers" or doing other special work, the measured amount of carbon dioxid, as determined by the aspirators, would be smaller than the amount actually eliminated, and vice versa.

The meter-pump method, briefly described in a previous bulletin,[b] affords, theoretically, an almost perfect means of sampling the ventilating air current. The arrangements for carrying out this method are as follows: The air from each fiftieth stroke of the pump is collected alternately in two tin receptacles, from which it is withdrawn by suction and passed through tubes filled with pumice stone and sulphuric acid, and with soda lime for the absorption of the water and carbon dioxid, respectively. In the earlier experiments in which the meter pump was used for moving the ventilating air current this method of sampling had not been perfected. In test experiments Nos. 9–12 the

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 63, pp. 34, 35.

[b] U. S. Dept. Agr., Office of Experiment Stations Bul. 63, p. 31.

carbon dioxid as determined in the sample drawn by the meter pump was slightly nearer the theoretical than the corresponding values obtained by the aspirators. Variations in the amounts of water as determined in the samples drawn by the meter pump were a little greater than those for carbon dioxid. The comparative results obtained by the two methods in test experiments Nos. 9–12 are shown in the following table:

TABLE 2.—*Comparison of determinations of carbon dioxid and water in the ventilating air current by means of the aspirators and of the meter pump.*

Test experiment.	Duration.	Carbon dioxid.					Water.				
		Theoretical amount from alcohol burned in lamp.	Determined—				Theoretical amount from alcohol burned in lamp.	Determined—			
			By meter pump.		By aspirators.			By meter pump.		By aspirators.	
	h. m.	*Grams.*	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*
9	35 55	1,206.9	1,199.2	99.4	1,198.9	99.3	809.3	830.6	102.6	807.9	99.8
10	35 44	1,159.8	1,163.9	100.3	1,087.0	93.7	772.5	773.5	100.1	739.7	95.8
11	35 00	1,304.2	1,293.7	99.2	1,287.9	98.7	869.8	878.2	101.0	877.8	100.9
12	27 56	1,075.4	1,067.7	99.3	1,083.2	100.7	717.2	705.7	98.4	705.0	98.3

There was on the whole but little difference between the results obtained by the two methods of sampling the ventilating air current, except in the determinations of water in No. 10. Since the meter pump theoretically should give a more accurate sample than the aspirators, and since the experimental evidence shows that the results with the pump were at least as accurate and sometimes more so than those with the aspirators, the determinations of carbon dioxid and water in the sample drawn by the meter pump were employed in the calculation of the results of all metabolism experiments made subsequent to metabolism experiment No. 11, although check determinations by means of the aspirators were continued during several experiments. In most of the experiments the discrepancies between the two methods were so insignificant as to be within the limit of experimental error, and show that the determination of carbon dioxid and water may be made with a satisfactory degree of accuracy by either of the methods.

EXPERIMENTS WITH MEN.

The general plan of the experiments here reported in detail was much the same as that followed in earlier experiments, the results of which have been published in former bulletins of this series.[a]

For the most part the experiments here reported were made in series, each series comprising three or more experiments which followed one another without intermission and without the subject

[a] U. S. Dept. Agr., Office of Experiment Stations Buls. 44, 63, and 69.

leaving the calorimeter. As a rule there was a change of diet in respect to one class of ingredients; for example, the replacement of sugar by an isodynamic amount of fat.

In all cases a preliminary period, usually of four days' duration, preceded each experiment or series of experiments with the subject in the chamber of the calorimeter. During this preliminary period the subject received the same diet as was to be served in the experiment which would immediately follow. In addition, the excretory products were collected and analyzed, thus making this period both a digestion and a nitrogen metabolism experiment. On the evening of the last day of the preliminary period the subject entered the chamber of the respiration calorimeter and usually retired at about 11 o'clock. At about 1 o'clock in the morning the heat measurements were begun in order to get the calorimeter into normal condition for the commencement of the second period, or the metabolism experiment proper, at 7 o'clock the following morning.

The programme followed during the experiment or series of experiments was arranged beforehand. A copy of it was furnished to the subject, and copies were also posted in convenient places for the guidance of those outside.

PREPARATION, SAMPLING, AND ANALYSIS OF FOODS.

The method of preparing, sampling, and analyzing the food materials was the same as that employed in experiments Nos. 9 and 10, already described.[a]

With the exception of milk, the proper quantity of each kind of food, either for each meal or for the day, was placed in glass jars previous to the beginning of the experiment, and materials which might spoil during the course of the experiment, such as meat and bread, were thoroughly sterilized. Butter and sugar, in quantity sufficient for each day, were passed in with the breakfast, and the subject used, as near as he could judge, the proportions called for by the menu for each meal. Sufficient bread for the day was usually passed in at breakfast time in two jars, and as nearly as possible the scheduled amounts used at each meal. Two or more duplicate jars of each food material, as thus prepared, were analyzed, the usual determinations being made according to the methods already described. The milk was obtained fresh each day; an aliquot portion was taken for the preparation of a composite sample for analysis, and the proper amounts for each of the three meals were placed in bottles.

In the following table is shown the percentage composition of the different food materials used in the thirteen experiments reported herewith. The values are for the fresh, edible material as served to the subject.

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 69, pp. 20–29, 88–89.

TABLE 3.—*Composition of food materials in metabolism experiments Nos. 11, 13, 14, 21, 23, 24, 25, 26, 28, 29, 31, 32, and 34.*

Laboratory No.	Food materials.	Experiment No.	Nitrogen.	Carbon.	Hydrogen.	Water.	Protein (N × 6.25).	Fat.	Carbohydrates	Ash.	Heat of combustion per gram, determined.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
2851	Beef, cooked	11	4.40	17.21	2.44	66.4	27.5	4.3	.....	1.8	1.920
2962	.....do	13	4.00	14.36	2.07	70.7	25.1	2.0	.....	2.4	1.577
2967	.....do	14	4.44	17.75	2.64	66.0	27.8	4.2	.....	1.7	1.964
3022	.....do	21	4.46	16.57	2.54	66.7	27.9	2.6	.....	2.1	1.827
3027	.....do	23, 24	5.59	23.57	3.37	56.6	34.9	6.1	.....	1.0	2.633
3165	.....do	25	5.36	19.62	2.76	62.8	33.5	3.3	.....	1.2	2.172
3176	.....do	26, 28	5.41	19.55	2.70	62.5	33.8	2.8	.....	.9	2.198
3186	.....do	29, 31	5.72	20.89	2.99	60.3	35.7	3.0	.....	1.0	2.327
3205	.....do	32, 34	5.13	18.55	2.66	64.5	32.1	2.8	.....	1.0	2.075
2853	Butter	11	.15	64.76	10.09	12.4	.9	84.3	.....	2.4	7.749
2956	.....do	13	.19	63.56	10.09	10.1	1.2	85.2	.....	3.5	7.806
2970	.....do	14	.19	62.55	10.20	10.6	1.2	85.5	.....	2.7	7.901
3021	.....do	21	.21	66.23	10.55	8.7	1.3	87.5	.....	2.5	8.178
3029	.....do	23, 24	.17	69.16	10.52	9.5	1.1	86.8	.....	2.6	8.027
3166	.....do	25	.25	63.37	10.01	8.8	1.6	86.1	.....	3.5	8.020
3177	.....do	26, 28	.26	65.02	10.02	9.9	1.6	85.9	.....	2.6	8.002
3187	.....do	29, 31	.20	65.11	10.44	9.2	1.3	86.3	.....	3.2	8.048
3206	.....do	32, 34	.20	65.58	10.37	8.4	1.3	87.6	.....	2.7	8.210
2855	Milk, skimmed	11	.52	4.01	.57	90.8	3.3	.1	5.0	.8	.381
2972	.....do	14	.61	4.35	.61	90.2	3.8	.1	5.0	.9	.439
3031	.....do	23, 24	.58	4.11	.59	90.7	3.6	.1	4.8	.8	.409
3169	.....do	25	.68	4.76	.67	89.4	4.3	.4	5.1	.8	.488
3179	.....do	26, 28	.67	4.63	.63	90.0	4.2	.3	4.7	.8	.462
3024	Milk, whole	21	.51	7.03	.94	86.6	3.2	4.4	5.0	.8	.782
3189	.....do	29	.66	8.20	1.26	84.5	4.1	5.6	5.0	.8	.935
3191	.....do	31	.65	8.25	1.26	84.5	4.1	5.6	5.0	.8	.939
3200	.....do	32	.66	7.95	1.19	85.4	4.1	5.0	4.7	.8	.905
3202	.....do	34	.66	8.20	1.21	85.2	4.1	5.2	4.3	.8	.913
2959	Milk, whole and skimmed, mixed	13	.58	6.93	1.04	86.7	3.6	3.2	5.7	.8	.753
2842	Maize breakfast food	11	1.88	44.39	6.49	4.9	11.8	8.2	73.4	1.7	4.437
2960	.....do	13, 14	1.78	44.81	6.42	5.7	11.1	8.3	72.9	2.0	4.467
2840	Wheat breakfast food	11	1.75	41.20	6.03	7.2	10.9	1.5	78.3	2.1	4.052
3004	Cereal, parched	21–24	1.82	41.39	6.17	6.1	11.4	.6	80.4	1.5	4.056
3168	.....do	25–28	1.87	42.20	5.94	5.6	11.7	1.7	79.1	1.9	4.136
3193	.....do	29–34	1.92	42.72	6.30	4.1	12.0	1.4	80.5	2.0	4.202
2852	Bread	11	1.42	26.07	3.82	42.7	8.9	1.5	45.7	1.2	2.575
2963	.....do	13	1.38	29.49	4.33	37.2	8.6	5.1	47.9	1.2	2.966
2968	.....do	14, 21	1.27	27.33	4.11	41.7	7.9	2.8	46.3	1.3	2.710
3032	.....do	23, 24	1.27	28.05	3.98	40.4	7.9	3.4	47.0	1.3	2.889
3164	.....do	25	1.46	28.04	4.03	38.6	9.1	2.1	48.9	1.3	2.805
3180	.....do	26, 28	1.42	27.76	3.99	39.3	8.9	1.6	48.9	1.3	2.803
3192	.....do	29, 31	1.50	29.14	4.30	36.5	9.4	2.0	50.8	1.3	2.930
3204	.....do	32, 34	1.38	28.27	4.30	37.8	8.6	2.5	49.8	1.3	2.869
2481	Ginger snaps	11	.92	42.73	6.45	4.3	5.8	6.2	80.8	2.9	4.247
3167	.....do	25	1.03	44.15	6.41	4.9	6.4	8.6	78.4	1.7	4.432
3181	.....do	26–31	1.00	44.32	6.61	4.1	6.2	8.3	79.8	1.6	4.434
3207	.....do	32, 34	.88	43.87	7.20	3.7	5.5	7.2	81.6	2.0	4.434
2961	Cookies	13	.86	44.65	6.68	5.2	5.4	10.8	76.7	1.9	4.460
2969	Ginger snaps	14	1.04	43.86	6.73	4.6	6.5	8.3	77.7	2.9	4.407
.....	Sugar	(a)	.....	42.10	6.48	.....	.....	.....	100.0	.....	3.960

a Used in all the experiments.

The composition of the feces in the experiments here reported is shown in the table which follows. The composition of the urine and the respiratory products is shown in connection with the tabular details of the individual experiments:

TABLE 4.—*Composition of feces in metabolism experiments Nos. 11, 13, 14, 21, 23, 24, 25, 26, 28, 29, 31, 32, and 34.*

Laboratory No.	Experiment No.	Nitrogen.	Carbon.	Hydrogen.	Water.	Protein (N × 6.25).	Fat.	Carbohydrates.	Ash.	Heat of combustion per gram, determined.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
2850	11	1.59	14.30	1.98	70.6	9.9	6.4	8.8	4.3	1.554
2965	13	1.49	15.04	2.14	69.8	9.3	8.3	7.0	5.6	1.689
2974	14	1.57	13.49	1.85	74.2	9.8	6.7	5.8	3.5	1.500
3033	21	1.62	14.03	1.94	72.6	10.1	6.3	6.3	4.7	1.571
3035	23	1.59	14.44	2.07	69.3	9.9	5.2	8.5	7.1	1.610
3036	24	1.45	11.64	1.65	75.7	9.1	4.9	5.4	4.9	1.282
3171	25	1.38	13.73	2.02	69.0	8.6	3.8	11.1	7.5	1.571
3183	26	1.38	11.98	1.44	72.3	8.7	3.6	8.5	6.9	1.340
3185	28	1.70	13.61	1.83	70.6	10.6	5.5	7.3	6.0	1.525
3195	29	1.44	14.13	2.03	69.9	9.0	5.1	10.3	5.7	1.574
3197	31	1.52	15.19	2.13	67.5	9.5	5.1	11.3	6.6	1.698
3209	32	1.21	12.87	1.86	73.2	7.6	4.5	9.6	5.1	1.449
3211	34	1.38	13.56	1.93	70.3	8.6	5.8	9.1	6.2	1.475

DETERMINATION OF NITRATES AND NITRITES IN THE WATER OF RESPIRATION.

Defren[a] calls attention to the presence of nitrates, and especially nitrites, in water of exhalation, and suggests the possibility of the nitrogen thus given off being sufficient in amount to take into account in studying the metabolism of nitrogen.

It is of great importance in experiments of the nature of these, in which the balance of income and outgo of nitrogen is determined with great care, to take account of any nitrogen which might thus be eliminated. Since in the experiments here reported the products of respiration are passed through a refrigerating system and cooled to a temperature of about −20° C., there is excellent opportunity for a study of this subject. Accordingly, in several of the experiments, and more particularly in work experiment No. 6, already reported,[b] the water condensed in the "freezers" was carefully preserved and tested qualitatively for both nitrates and nitrites. The water condensed from the incoming air was tested in a similar manner. Similar tests were also made of the water condensed on the surface of the absorbers and collected thence as "drip."

[a] Technology Quarterly, 9 (1896), p. 238. See also Experiment Station Record, 8, p. 385.

[b] U. S. Dept. Agr., Office of Experiment Stations Buls. 63, pp. 77–85; 69, pp. 47–60.

The test for nitrites was made in the usual way. A few cubic centimeters of a solution of metaphenylene-diamine in dilute sulphuric acid is placed in a test tube; a few drops of the water to be tested are allowed to fall into the test tube; if nitrites are present, a yellow color is produced.

This test is said to show nitrites when present in as dilute a solution as 1 part in 3,000,000, but in no case was any appreciable evidence of nitrites obtained in the water condensed in the freezers. In only one case was there sufficient coloration to warrant the statement that there was even a trace of nitrites present. Singularly enough, while the respired water condensed in the freezers gave no response to the test for nitrites, that condensed on the cooling apparatus in the respiration chamber gave a very marked nitrite reaction.

The test for nitrates was made by means of a solution of diphenylamine in rather strong sulphuric acid. Two or three cubic centimeters of this solution is placed in a test tube and about one-half a cubic centimeter of the water to be tested is allowed to flow slowly down the side of the test tube so that the two liquids do not mix. If a deep-blue ring appears at the contact zone of the two liquids, the presence of nitrates is shown. The results of the test for nitrates were very marked, but there appeared to be little difference between the amount in the water of the incoming and outgoing ventilating air current. After making a check experiment with the alcohol lamp burning inside the chamber the amount of nitrates in the outgoing freezer water appeared to be materially increased. This is not surprising, as the high temperature of the alcohol flame might naturally be expected to bring about a certain amount of combustion of the nitrogen of the air.

The test for nitrates and nitrites in the condensed water of respiration indicated that the actual amounts of these were so minute as to be ignored. It seems highly improbable that any measurable quantity of nitrogen can be excreted in this manner.

RECORDS OF BODY WEIGHT, TEMPERATURE, AND PULSE RATE.

The subject weighed himself on a platform scale sensitive to 10 grams with a weight of 75 kilograms and capable of weighing 100 kilograms.

The observations of body temperature were made by the use of an ordinary clinical thermometer. They were sublingual in experiments previous to, and axillary in experiments subsequent to, No. 25. In this latter experiment temperatures were measured in both ways. All observations were, of course, made by the subject himself. Under such circumstances it is not improbable that there may have been occasional errors in the thermometer readings; at best, such observations would be less satisfactory than those which would show the actual internal temperature of the body. In later experiments, the

results of which are not yet ready for publication, the body temperature was measured by a specially devised electrical thermometer inserted in the rectum, by which differences in body temperature of 0.02° could be detected.[a]

The observations of the pulse rate were also made by the subject. How observations made by a person upon himself compare in reliability with those made by another person we are unable to say.

The reading and recording of weights and measurements of food and excretory products and the other determinations outside the chamber are controlled either by repeating the observations or by having the quantities observed and recorded by two different persons or otherwise. The conditions for the reading and recording of figures for body weight, temperature, and pulse rate by the subject in the respiration chamber do not permit of so careful a system of checks for avoiding errors in the reading and recording of the figures. For this reason, and because of the uncertainties regarding the value of the observations of temperature and pulse rate just named, the figures for body weight, temperature, and pulse rate are hardly as reliable as those for the other determinations.

MEASUREMENT OF MUSCULAR WORK.

In the rest experiments the subjects moved about within the apparatus as little as possible, thus avoiding all unnecessary muscular exertion. In the work experiments, however, they were engaged in active muscular work for eight hours each day. The apparatus used for measuring the work in experiment No. 11 consisted of a bicycle belted to a small dynamo, as in experiment No. 6.[b] The voltage of the electric current generated was measured, and together with calibrations of the apparatus gave sufficient data for computing roughly the amount of work done by the subject.

In the work experiments carried on during the winter of 1900 (experiments Nos. 29, 31, 32, and 34) the apparatus was so modified as to give, it is believed, a more accurate measure of the work done.

In these experiments the rear wheel of the bicycle was applied directly to a pulley fastened to the shaft of the dynamo, which was mounted upon a rocking base, the necessary tension being secured by means of a coiled spring which kept the pulley of the dynamo pressed against the tire of the bicycle. This apparatus was calibrated before and after each experiment. Inasmuch, however, as the method of calibration was greatly improved in the experiments made during the winter and spring of 1901, further description of the apparatus and the methods of measuring the work done is not given in the present publication.

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[a] Arch. Physiol. [Pflüger], 88 (1901), No. 9–10, p. 492.

[b] U. S. Dept. Agr., Office of Experiment Stations Buls. 63, p. 76; 69, p. 41.

DETAILS OF THE EXPERIMENTS.

The details of thirteen experiments with three different subjects are recorded in the following pages. The methods of calculation were in general the same as those described in a previous publication.[a] In many cases the derivation of the values is indicated algebraically in the column headings of the tables.

METABOLISM EXPERIMENT NO. 11.

Subject.—E. O., the laboratory assistant who served as the subject in experiments Nos. 1 and 2, in which the necessary data for estimating the income and outgo of energy were not determined,[b] and in experiments Nos. 5–10, in which these values were determined.[c] He was 32 years of age, 5 feet 8 inches in height, and weighed without clothing about 70 kilograms (154 pounds).

Occupation during experiment.—Worked 8 hours a day upon the stationary bicycle just described. During evenings he passed the time in reading, writing, and resting.

Duration.—Four days, beginning at 7 a. m. March 22, 1898. The preliminary period of this experiment began with breakfast March 18. The subject entered the calorimeter on the evening of March 21, and remained until 7 a. m. March 26, thus spending five nights and four days in the respiration chamber.

Diet.—The diet during the experiment consisted of beef, butter, skim milk, bread, ginger snaps, cereal breakfast foods, sugar, and coffee, and furnished 124 grams of protein and 3,862 calories of energy per day. This experiment was intended to be much the same as experiment No. 9,[d] with the exception that the diet should furnish a considerably larger amount of energy, and a considerable amount of muscular work should be performed each day. The kinds and quantities of food served at each meal were as follows:

TABLE 5.—*Diet in metabolism experiment No. 11.*

Food materials.	Breakfast.	Dinner.	Supper.	Total.
	Grams.	*Grams.*	*Grams.*	*Grams.*
Beef	70	100	.....	170
Butter	40	40	40	120
Milk, skimmed	150	210	390	750
Bread	100	100	100	300
Maize breakfast food	60	.....	50	110
Wheat breakfast food	.....	75	.....	75
Ginger snaps	.....	.....	75	75
Sugar	35	40	35	110

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 69, p. 31, et seq.
[b] U. S. Dept. Agr., Office of Experiment Stations Bul. 44.
[c] U. S. Dept. Agr., Office of Experiment Stations Buls. Nos. 63 and 69.
[d] U. S. Dept. Agr., Office of Experiment Stations Bul. 69.

The amount of drink varied from day to day. On the first day the subject was given 600 grams of coffee infusion and 600 grams of water, making a total of 1,200 grams; on the second and third days 600 grams of coffee infusion and 800 grams of water, making a total of 1,400 grams, and on the last day 600 grams of coffee infusion and 1,500 grams of water, making a total of 2,100 grams.

The general routine of the experiment is indicated in the following schedule. The statistics of the diary kept by the subject are summarized in Table 7:

TABLE 6.—*Daily programme—Metabolism experiment No. 11.*

7.00 a. m	Rise, pass urine, collect drip, weigh absorbers, weigh self stripped and dressed.	1.50 p. m	Begin work.
		3.50 p. m	Stop work, rest 10 minutes, drink 200 grams water.
7.45 a. m	Breakfast.	4.00 p. m	Begin work.
8.20 a. m	Begin work.	6.00 p. m	Stop work.
10.20 a. m	Rest 10 minutes, drink 200 grams water.	6.30 p. m	Supper, change underclothes, weigh self stripped and dressed.
10.30 a. m	Begin work.	7.00 p. m	Pass urine, collect drip, weigh absorbers.
12.30 p. m	Stop work.		
1.00 p. m	Pass urine, collect drip, weigh absorbers.	10.00 p. m	Take cover off food aperture, retire.
1.15 p. m	Dinner.	1.00 a. m	Pass urine.

TABLE 7.—*Summary of diary—Metabolism experiment No. 11.*

Time.	Weight of subject.		Pulse, rate per minute.	Temperature.	Hygrometer readings.	
	Without clothes.	With clothes.			Dry bulb.	Wet bulb.
1898.	*Kilograms.*	*Kilograms.*		°F.	°C.	°C.
Mar. 22, 7.00 a. m	70	73.60	.....	.....	22	17.2
12.50 a. m	.....	.....	68	99	21.8	17.4
7.00 p. m	70.27	73.29	.....	.....	.....	.....
10.00 p. m	.....	.....	68	98.8	21.4	17.6
Mar. 23, 7.00 a. m	69.82	73.30	58	97	21.8	17
12.45 p. m	.....	.....	78	100	21.3	19
7.00 p. m	69.50	73.25	.....	.....	.....	.....
10.00 p. m	.....	.....	75	97.4	.....	.....
Mar. 24, 7.00 a. m	69.48	72.90	63	97.3	21.9	18.8
1.00 p. m	.....	.....	74	99.6	21.5	18.8
7.00 p. m	68.80	72.60	.....	.....	.....	.....
9.20 p. m	.....	.....	72	97	22	19
Mar. 25, 7.00 a. m	68.45	72.30	60	97	22	18
1.00 p. m	.....	.....	76	99.2	21.4	19
7.00 p. m	68.26	72.23	.....	.....	21.6	19.4
9.15 p. m	.....	.....	72	.....	.....	.....
Mar. 26, 7.00 a. m	67.95	72.10	.....	.....	.....	.....

Amount of work done.—As already stated, the subject worked 8 hours each day upon a stationary bicycle so arranged that the work performed was transformed into heat within the apparatus and

measured directly with that given off by the subject. A cyclometer registered the number of miles that would have been covered by the same number of revolutions of the wheel, but the amount of work done could hardly have been as large as would be required to propel a bicycle the number of miles thus recorded. It will be observed from the figures in Table 8 that there was considerable difference in the amount of work done on the different days of the study.

TABLE 8.—*Record of work done—Metabolism experiment No. 11.*

Time.	Cyclometer reading.	Number of miles.	(*a*) Actual duration of work.	(*b*) Rate.	(*c*) Heat equivalent, $a \times b \times 0.2378$
1898.			*Seconds.*	*Watts.*	*Calories.*
Mar. 22, 8.20 a. m	154				
10.20 a. m	182	28	7,200	25	86
12.40 p. m	210	28	7,200		
3.50 p. m	238	28	7,200	21	72
6.00 p. m	266	28	7,200		
Mar. 23, 8.20 a. m	266				
10.20 a. m	294	28	7,200	22	75
12.30 p. m	337	43	7,200		
3.50 p. m	379	42	7,200	28	96
6.00 p. m	415	36	7,200		
Mar. 24, 8.20 a. m	415				
10.20 a. m	447	32	7,200	26	89
12.30 p. m	479	32	7,200		
3.50 p. m	(1)	(1)	7,200	25	85
6.00 p. m	(1)	(1)	7,200		
Mar. 25, 8.20 a. m	479				
10.20 a. m	514	35	7,200	30	103
12.30 p. m	551	37	7,200		
3.50 p. m	588	37	7,200	41	140
6.00 p. m	644	26	7,200		
Total					746

[1] Cyclometer not working.

Detailed data of income and outgo.—The quantities of nutrients in the food consumed each day and the quantities rejected in the feces are shown in Tables 9 and 10. It will be observed by comparison with the results of some of the rest experiments reported in preceding bulletins, that, while the protein is practically the same as in these rest experiments, the energy in the food has been increased more than 800 calories per day in order to supply the necessary energy for the increased muscular activity. It was quite interesting to note that with

increased diet and with increased work the total amount of unavailable material excreted in the feces was considerably larger than in experiment No. 9. There was not enough difference, however, in the coefficients of availability to show whether muscular work had any marked effect upon the digestion of the food by the subject.

TABLE 9.—*Weight, composition, and heat of combustion of foods—Metabolism experiment No. 11.*

Laboratory No.	Food materials.	Weight per day.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
2851	Beef	170	112.9	46.8	7.3	.....	7.48	29.26	4.15	326
2853	Butter	120	14.9	.9	101.0	.....	.15	77.71	12.11	930
2855	Skimmed milk	750	681.0	24.4	1.5	37.5	3.90	30.08	4.28	286
2852	Bread	300	128.1	26.6	4.5	137.1	4.26	78.21	11.46	773
2842	Maize breakfast food	110	5.4	12.9	9.0	80.7	2.07	48.90	7.15	488
2840	Wheat breakfast food	75	5.4	8.2	1.1	58.7	1.31	30.90	4.52	304
2841	Ginger snaps	75	3.2	4.3	4.7	60.6	.69	32.09	4.85	319
	Sugar	110	.....	.....	.....	110.0	.....	46.31	.13	436
	Total	1,710	950.9	124.1	129.1	484.6	19.86	373.46	55.65	3,862

TABLE 10.—*Weight, composition, and heat of combustion of feces—Metabolism experiment No. 11.*

Laboratory No.		Weight of feces.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
2850.	Total, 4 days	563	398.0	56.4	36.0	49.6	8.96	80.51	11.15	875
	Average, 1 day	141	99.5	14.1	9.0	12.4	2.24	20.13	2.79	219

The urine in this experiment was collected in 6-hour periods, and the specific gravity and nitrogen content determined. The heat of combustion was determined in a composite sample of the urine for each day, and the carbon and hydrogen in a composite sample for the four days of the experiment. The methods employed for determining the heat of combustion and for computing the carbon and hydrogen in the urine of each day have already been described.[a] The statistics of the outgo of matter in the urine in this experiment are given in Table 11.

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 69, pp. 23 and 35.

TABLE 11.—*Amount, specific gravity, and nitrogen of urine by six-hour periods—Metabolism experiment No. 11.*

Date.	Period.	Amount.	Specific gravity.	Nitrogen.	
1898.		*Grams.*		*Per cent.*	*Grams.*
Mar. 22-23	7 a. m. to 1 p. m	326.0	1.027	1.25	4.08
	1 p. m. to 7 p. m	350.6	1.027	1.34	4.70
	7 p. m. to 1 a. m	292.3	1.033	1.87	5.46
	1 a. m. to 7 a. m	146.8	1.031	2.10	3.08
	Total	1,115.7			17.32
	Total by composite	1,115.7		1.53	17.07
23-24	7 a. m. to 1 p. m	206.5	1.028	1.76	3.63
	1 p. m. to 7 p. m	311.3	1.031	1.61	5.01
	7 p. m. to 1 a. m	211.0	1.036	2.26	4.77
	1 a. m. to 7 a. m	150.1	1.032	2.30	3.45
	Total	878.9			16.86
	Total by composite	878.9		1.92	16.87
24-25	7 a. m. to 1 p. m	218.3	1.030	1.89	4.13
	1 p. m. to 7 p. m	315.4	1.030	1.62	5.11
	7 p. m. to 1 a. m	251.0	1.035	2.28	5.72
	1 a. m. to 7 a. m	133.6	1.034	2.36	3.15
	Total	918.3			18.11
	Total by composite	918.3		2.00	18.37
25-26	7 a. m. to 1 p. m	236.0	1.031	1.65	4.60
	1 p. m. to 7 p. m	304.8	1.032	1.80	5.48
	7 p. m. to 1 a. m	273.4	1.035	2.31	6.32
	1 a. m. to 7 a. m	120.0	1.037	2.32	2.78
	Total	934.2			19.18
	Total by composite	934.2		2.05	19.15
	Total, 4 days, by periods	3,847.1			71.47
26	7 a. m. to 1 p. m	157.5	1.032	2.05	3.24
	1 p. m. to 7 p. m	216.4	1.032	1.90	4.10

TABLE 12.—*Daily elimination of carbon, hydrogen, water, and energy in urine—Metabolism experiment No. 11.*

Date.	Amount of urine.	Carbon.		Hydrogen.		Water.		Heat of combustion.	
								Per gram.	Total.
1898.	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*Calorie.*	*Calories.*
Mar. 22-23	1,115.7	.....	12.30	.....	3.54	.....	1,050.1	0.126	141
23-24	878.9	.....	11.98	.....	3.45	.....	815.0	.162	142
24-25	918.3	.....	12.87	.....	3.71	.....	849.7	.129	118
25-26	934.2	.....	13.63	.....	3.92	.....	861.5	.141	132
Total, 4 days	3,847.1	1.32	50.78	0.38	14.62	92.96	3,576.3	(.139)	[a]533

[a] The heat of combustion of the urine was determined in the composite sample for each day and in the total composite for four days. The heat of combustion of the urine for the experiment as determined in this latter sample amounted to 0.139 calorie per gram, or a total of 535 calories for the urine of the whole experiment.

Tables 13–15 give the results of the determinations of carbon dioxid and water in the ventilating air current. The method of calculation of these tables has been described in some detail in connection with the description of results of experiment No. 5, reported in an earlier publication.[a] The formulas in the column headings in some of the tables indicate the method by which many of the calculations are made. The drip was collected but once a day and the amount has been equally apportioned among the four periods of the day. While this is undoubtedly erroneous, it has, in view of the lack of any data, seemed the most satisfactory plan. Should some other method of subdivision seem desirable, all data are given by means of which computations can be readily made. The error involved, however, does not affect the final results of the experiments, as the total quantities per day are used in the computations.

TABLE 13.—*Comparison of residual amounts of carbon dioxid and water in the chamber at the beginning and end of each period, and the corresponding gain or loss—Metabolism experiment No. 11.*

Date.	End of period.	Carbon dioxid.		Water.				
		Total amount in chamber.	Gain (+) or loss (−) over preceding period.	Total amount of vapor remaining in chamber.	Gain (+) or loss (−) over preceding period.	Change in weight of absorbers, gain (+) or loss (−).	Drip from absorbers.	Total amount gained (+) or lost (−) during the period.
1898.		*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 22–23	7 a. m	29.7	.....	45.0	.....	.....	.....	.....
	1 p. m	82.3	+52.6	54.9	+ 9.9	+194	114.5	318.4
	7 p. m	64.4	−17.9	57.1	+ 2.2	− 22	114.6	94.8
	1 a. m	30.5	−33.9	52.3	− 4.8	− 27	114.6	82.8
	7 a. m	28.7	− 1.8	47.8	− 4.5	− 28	114.6	82.1
	Total	.....	− 1.0	.....	+ 2.8	+117	458.3	578.1
23–24	1 p. m	91.3	+62.6	56.6	+ 8.8	+235	152.0	395.8
	7 p. m	72.8	−18.5	56.8	+ .2	+ 7	152.0	159.2
	1 a. m	26.6	−46.2	53.3	− 3.5	− 2	152.0	146.5
	7 a. m	26.8	+ .2	53.2	− .1	− 1	152.0	150.9
	Total	.....	− 1.9	.....	+ 5.4	+239	608.0	852.4
24–25	1 p. m	90.9	+64.1	61.0	+ 7.8	+ 57	280.1	344.9
	7 p. m	76.7	−14.2	63.5	+ 2.5	+248	280.0	530.5
	1 a. m	25.2	−51.5	57.3	− 6.2	−294	280.0	− 20.2
	7 a. m	26.3	+ 1.1	55.6	− 1.7	−295	280.0	− 16.7
	Total	.....	− .5	.....	+ 2.4	−284	1,120.1	838.5
25–26	1 p. m	98.8	+72.5	62.9	+ 7.3	+177	341.7	526.0
	7 p. m	82.0	−16.8	66.7	+ 3.8	+155	341.7	500.5
	1 a. m	32.3	−49.7	56.7	−10.0	−223	341.6	108.6
	7 a. m	35.0	+ 2.7	56.8	+ .1	−222	341.6	119.7
	Total	.....	+ 8.7	.....	+ 1.2	−113	1,366.6	1,254.8
	Total, 4 days	.....	.....	.....	+11.8	− 41	3,553.0	3,523.8

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 69.

TABLE 14.—*Record of carbon dioxid—Metabolism experiment No. 11.*

Date.	Period.	(a) Ventilation (number of liters of air).	Carbon dioxid. (b) In incoming air (per liter).	(c) In outgoing air (per liter).	(d) Excess in outgoing air (per liter), $c-b$	(e) Total excess in outgoing air, $d \times a$.	(f) Correction for carbon dioxid in apparatus.	(g) Corrected weight carbon dioxid exhaled by subject, $e+f$.	(h) Total weight of carbon exhaled in carbon dioxid, $g \times \frac{3}{11}$.
1898.		*Liters.*	*Mg.*	*Mgs.*	*Mgs.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 22-23	7 a. m. to 1 p. m.	27,787	0.615	14.229	13.614	377.3	+52.6	429.9	117.3
	1 p. m. to 7 p. m.	28,013	.601	15.161	14.560	407.9	−17.9	390.0	106.3
	7 p. m. to 1 a. m.	28,740	.553	9.955	9.402	270.2	−33.9	236.3	64.4
	1 a. m. to 7 a. m.	28,954	.611	5.474	4.863	140.9	− 1.8	139.1	37.9
	Total	113,444	.....	.....	.....	1,196.3	− 1.0	1,195.3	325.9
23-24	7 a. m. to 1 p. m.	27,332	.582	15.586	15.004	410.1	+62.6	472.7	128.9
	1 p. m. to 7 p. m.	27,437	.742	20.249	19.507	535.2	−18.5	516.7	140.9
	7 p. m. to 1 a. m.	28,213	.551	10.045	9.494	267.9	−46.2	221.7	60.5
	1 a. m. to 7 a. m.	28,899	.611	5.817	5.206	150.5	+ .2	150.7	41.1
	Total	111,881	.....	.....	.....	1,363.7	− 1.9	1,361.8	371.4
24-25	7 a. m. to 1 p. m.	28,257	.586	17.465	16.879	476.8	+64.1	540.9	147.5
	1 p. m. to 7 p. m.	27,779	.561	19.690	19.129	531.4	−14.2	517.2	141.1
	7 p. m. to 1 a. m.	28,359	.568	9.542	8.979	254.6	−51.5	203.1	55.4
	1 a. m. to 7 a. m.	28,814	.599	5.312	4.713	135.8	+ 1.1	136.9	37.3
	Total	113,209	.....	.....	.....	1,398.6	− .5	1,398.1	381.3
25-26	7 a. m. to 1 p. m.	28,094	.594	17.259	16.665	468.2	+72.5	540.7	147.5
	1 p. m. to 7 p. m.	27,648	.586	22.508	21.922	606.1	−16.8	589.3	160.7
	7 p. m. to 1 a. m.	28,545	.508	10.060	9.552	272.7	−49.7	223.0	60.8
	1 a. m. to 7 a. m.	28,254	.641	6.103	5.462	154.3	+ 2.7	157.0	42.8
	Total	112,541	.....	.....	.....	1,501.3	+ 8.7	1,510.0	411.8
	Total, 4 days	451,075	.....	.....	.....	5,459.9	+ 5.3	5,465.2	1,490.4

TABLE 15.—*Record of water—Metabolism experiment No. 11.*

Date.	Period.	(a) Ventilation (number of liters of air).	Water. (b) In incoming air (per liter).	(c) In outgoing air (per liter).	(d) Excess in outgoing air (per liter), $c-b$.	(e) Total excess in outgoing air, $d \times a$.	(f) Condensed in freezers.	(g) Correction for water remaining in chamber.	(h) Total water exhaled, $e+f+g$.
1898.		*Liters.*	*Mg.*	*Mgs.*	*Mg.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 22–23	7 a. m. to 1 p. m.	27,737	0.888	1.459	0.571	15.8	255.1	318.4	589.3
	1 p. m. to 7 p. m.	28,013	.795	1.315	.520	15.0	304.4	94.8	414.2
	7 p. m. to 1 a. m.	28,740	.689	1.380	.691	19.9	298.1	82.8	400.8
	1 a. m. to 7 a. m.	28.954	.681	1.072	.391	11.3	260.7	82.1	354.1
	Total	113,444				62.0	1,118.3	578.1	1,758.4
23–24	7 a. m. to 1 p. m.	27,332	.844	1.571	.727	19.9	268.6	395.8	684.3
	1 p. m. to 7 p. m.	27,437	.826	1.345	.519	14.2	350.4	159.2	523.8
	7 p. m. to 1 a. m.	28,213	.648	1.270	.622	17.6	341.6	146.5	505.7
	1 a. m. to 7 a. m.	28,899	.619	1.092	.473	13.7	298.8	150.9	463.4
	Total	111,881				65.4	1,259.4	852.4	2,177.2
24–25	7 a. m. to 1 p. m.	28,257	.824	1.640	.816	23.1	318.4	344.9	686.4
	1 p. m. to 7 p. m.	27,779	.788	1.409	.621	17.2	357.8	530.5	905.5
	7 p. m. to 1 a. m.	28,359	.713	1.429	.716	20.3	340.8	− 20.2	340.9
	1 a. m. to 7 a. m.	28,814	.670	1.139	.469	13.5	301.5	− 16.7	298.3
	Total	113,209				74.1	1,318.5	838.5	2,231.1
25–26	7 a. m. to 1 p. m.	28,094	.875	1.862	.987	27.7	297.6	526.0	851.3
	1 p. m. to 7 p. m.	27,648	.782	1.463	.681	18.8	367.3	500.5	886.6
	7 p. m. to 1 a. m.	28,545	.628	1.374	.746	21.3	342.8	108.6	472.7
	1 a. m. to 7 a. m.	28,254	.607	1.078	.471	13.3	293.6	119.7	426.6
	Total	112,541				81.1	1,301.3	1,254.8	2,637.2
	Total, 4 days	451,075				282.6	4,997.5	3,523.8	8,803.9

Table 16 gives the summary of the calorimetric measurements during this experiment:

TABLE 16.—*Summary of calorimetric measurements—Metabolism experiment No. 11.*

Date.	Period.	(*a*) Heat measured in terms of C_{20}	(*b*) Change of temperature of calorimeter.	(*c*) Capacity correction of calorimeter, $b \times 60$.	(*d*) Correction due to temperature of food and dishes.	(*e*) Water vaporized equals total amount exhaled less amount condensed in chamber.	(*f*) Heat used in vaporization of water, $e \times 0.592$.	(*g*) Total heat determined, $a+c+d+f$.
1898.		*Calories.*	*Degree.*	*Calories.*	*Calories.*	*Grams.*	*Calories.*	*Calories.*
Mar. 22–23	7 a. m. to 1 p. m..	1,018.9	+0.15	+ 9.0	−22.5	280.8	166.2	1,171.6
	1 p. m. to 7 p. m..	965.6	+ .25	+15.0	−14.1	321.6	190.5	1,157.0
	7 p. m. to 1 a. m..	534.6	− .15	− 9.0	.....	313.2	185.4	711.0
	1 a. m. to 7 a. m..	275.4	.....	.....	.....	267.5	158.4	433.8
	Total.....	2,794.5	.....	+15.0	−36.6	1,183.1	700.5	3,473.4
23–24	7 a. m. to 1 p. m..	1,032.5	+ .20	+12.0	−13.5	297.3	176.0	1,207.0
	1 p. m. to 7 p. m..	1,364.2	− .40	−24.0	− 8.0	364.8	215.9	1,548.1
	7 p. m. to 1 a. m..	482.5	+ .20	+12.0	.....	355.7	210.6	705.1
	1 a. m. to 7 a. m..	272.	− .10	− 6.0	.....	312.4	184.9	451.1
	Total.....	3,151.4	.....	− 6.0	−21.5	1,330.2	787.4	3,911.3
24–25	7 a. m. to 1 p. m..	1,247.6	+ .05	+ 3.0	−14.4	349.3	206.8	1,443.0
	1 p. m. to 7 p. m..	1,305.5	− .10	− 6.0	− 2.6	377.5	223.5	1,520.4
	7 p. m. to 1 a. m..	428.9	+ .15	+ 9.0	.....	354.9	210.1	648.0
	1 a. m. to 7 a. m..	253.5	+ .05	+ 3.0	.....	313.3	185.5	442.0
	Total.....	3,235.5	.....	+ 9.0	−17.0	1,395.0	825.9	4,053.4
25–26	7 a. m. to 1 p. m..	1,229.0	− .15	− 9.0	−11.9	332.6	196.9	1,405.0
	1 p. m. to 7 p. m..	1,436.5	+ .10	+ 6.0	+17.7	389.9	230.8	1,691.0
	7 p. m. to 1 a. m..	510.4	− .10	− 6.0	.....	354.1	209.6	714.0
	1 a. m. to 7 a. m..	299.3	− .05	− 3.0	.....	306.0	181.1	477.4
	Total.....	3,475.2	.....	−12.0	+ 5.8	1,382.6	818.4	4,287.4
	Total, 4 days .	12,656.6	.....	+ 6.0	-69.3	5,290.9	3,132.2	15,725.5

Balance of income and outgo of matter and energy.—The original data of income and outgo of matter and energy in this experiment may be found in the preceding tables. Tables 17–20, which follow, summarize the results of the experiment, showing the estimated gain or loss of body material, and comparing the estimated energy of the material oxidized in the body with the heat actually determined by means of the respiration calorimeter. In Table 17 the figures in the third column, nitrogen in urine, include the nitrogen of perspiration, which amounted to 0.2 gram per day; and the figures for water in respiratory products in the fifth column of Table 18 include the water of perspiration which was absorbed and removed by the underclothing of the subject, which was changed each night.[a]

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 69, pp. 24 and 52.

TABLE 17.—*Income and outgo of nitrogen and carbon—Metabolism experiment No. 11.*

Time.	Nitrogen.				Carbon.				
	(*a*) In food.	(*b*) In feces.	(*c*) In urine.[a]	(*d*) Gain (+) or loss (−) $a-(b+c)$.	(*e*) In food.	(*f*) In feces.	(*g*) In urine.	(*h*) In respiratory products.	(*k*) Gain (+) or loss (−), $e-(f+g+h)$.
1898.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 22–23, 7 a. m. to 7 a. m.	19.8	2.2	17.5	+0.1	373.4	20.1	12.3	325.9	+ 15.1
23–24, 7 a. m. to 7 a. m.	19.9	2.3	17.1	+ .5	373.5	20.2	12.0	371.4	− 30.1
24–25, 7 a. m. to 7 a. m.	19.8	2.2	18.3	− .7	373.4	20.1	12.9	381.3	− 40.9
25–26, 7 a. m. to 7 a. m.	19.9	2.3	19.4	−1.8	373.5	20.2	13.6	411.8	− 72.1
Total, 4 days	79.4	9.0	72.3	−1.9	1,493.8	80.6	50.8	1,490.4	−128.0
Average, 1 day	19.8	2.2	18.1	− .5	373.5	20.2	12.7	372.6	− 32.0

[a] Including nitrogen in perspiration, which amounted to 0.2 gram per day.

TABLE 18.—*Income and outgo of water and hydrogen—Metabolism experiment No. 11.*

Time.	Water.					
	(*a*) In food.	(*b*) In drink.	(*c*) In feces.	(*d*) In urine.	(*e*) In respiratory products.[a]	(*f*) Apparent loss, $a+b-(c+d+e)$.
1898.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 22–23, 7 a. m. to 7 a. m.	950.9	1,200	99.5	1,050.1	1,762.2	− 760.9
23–24, 7 a. m. to 7 a. m.	950.9	1,400	99.5	815.0	2,190.4	− 754.0
24–25, 7 a. m. to 7 a. m.	950.9	1,400	99.5	849.7	2,256.1	− 854.4
25–26, 7 a. m. to 7 a. m.	950.9	2,100	99.5	861.5	2,699.2	− 609.3
Total, 4 days	3,803.6	6,100	398.0	3,576.3	8,907.9	−2,978.6
Average, 1 day	950.9	1,525	99.5	894.1	2,227.0	− 744.7

Time.	Hydrogen.					
	(*g*) In food.	(*h*) In feces.	(*i*) In urine.	(*l*) Apparent gain, $g-(h+i)$.	(*m*) Loss from water, $f+9$.	(*n*) Total gain (+) or loss (−), $l+m$.
1898.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 22–23, 7 a. m. to 7 a. m.	55.6	2.8	3.5	49.3	84.6	− 35.3
23–24, 7 a. m. to 7 a. m.	55.7	2.8	3.5	49.4	83.8	− 34.4
24–25, 7 a. m. to 7 a. m.	55.6	2.8	3.7	49.1	94.9	− 45.8
25–26, 7 a. m. to 7 a. m.	55.7	2.8	3.9	49.0	67.7	− 18.7
Total, 4 days	222.6	11.2	14.6	196.8	331.0	−134.2
Average, 1 day	55.7	2.8	3.7	49.2	82.7	− 33.5

[a] Includes water from perspiration in clothes—3.8 grams first day, 13.2 second day, 25 third day, and 62 fourth day, a total of 104 grams.

TABLE 19.—*Gain or loss of protein (N×6.25), fat, and water—Metabolism experiment No. 11.*

Time.	(*a*) Nitrogen gained (+) or lost (−).	(*b*) Protein gained (+) or lost (−), *a*×6.25.	(*c*) Total carbon gained (+) or lost (−).	(*d*) Carbon in protein gained (+) or lost (−), *b*×0.53.	(*e*) Carbon in fat, etc., gained (+) or lost (−), *c*−*d*.	(*f*) Fat gained (+) or lost (−), *e*÷0.765.
1898.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 22–23, 7 a. m. to 7 a. m	+0.1	+ 0.6	+ 15.1	+0.3	+ 14.8	+ 19.3
23–24, 7 a. m. to 7 a. m	+ .5	+ 3.1	− 30.1	+1.6	− 31.7	− 41.4
24–25, 7 a. m. to 7 a. m	− .7	− 4.4	− 40.9	−2.3	− 38.6	− 50.5
25–26, 7 a. m. to 7 a. m	−1.8	−11.2	− 72.1	−5.9	− 66.2	− 86.5
Total, 4 days	−1.9	−11.9	−128.0	−6.3	−121.7	−159.1
Average, 1 day	− .5	− 3.0	− 32.0	−1.6	− 30.4	− 39.7

Time.	(*g*) Total hydrogen gained (+) or lost (−).	(*h*) Hydrogen in protein gained (+) or lost (−), *b*×0.07.	(*i*) Hydrogen in fat gained (+) or lost (−), *f*×0.12.	(*k*) Hydrogen in water, etc., gained (+) or lost (−), *g*−(*h*+*i*).	(*l*) Water gained (+) or lost (−), *k*×9.
1898.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 22–23, 7 a. m. to 7 a. m	− 35.3	0.0	+ 2.3	− 37.6	− 338.4
23–24, 7 a. m. to 7 a. m	− 34.4	+ .2	− 5.0	− 29.6	− 266.4
24–25, 7 a. m. to 7 a. m	− 45.8	− .3	− 6.1	− 39.4	− 354.6
25–26, 7 a. m. to 7 a. m	− 18.7	− .8	−10.4	− 7.5	− 67.5
Total, 4 days	−134.2	− .9	−19.2	−114.1	−1,026.9
Average, 1 day	− 33.5	− .2	− 4.8	− 28.5	− 256.7

TABLE 20.—*Income and outgo of energy—Metabolism experiment No. 11.*

Time.	(*a*) Heat of combustion of food eaten.	(*b*) Heat of combustion of feces.	(*c*) Heat of combustion of urine.	(*d*) Estimated heat of combustion of protein gained (+) or lost (−)	(*e*) Estimated heat of combustion of fat gained (+) or lost (−)	(*f*) Estimated energy of material oxidized in the body, *a*−(*b*+*c*+*d*+*e*).	(*g*) Heat determined.	(*h*) Heat determined greater (+) or less (−) than estimated, *g*−*f*.	(*i*) Heat determined greater (+) or less (−) than estimated, *h*÷*f*.
1898.	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Per ct.*
Mar. 22–23, 7 a. m. to 7 a. m.	3,862	219	141	+ 3	+ 181	3,318	3,473	+155	+4.7
23–24, 7 a. m. to 7 a. m.	3,862	219	142	+18	− 389	3,872	3,911	+ 39	+1.0
24–25, 7 a. m. to 7 a. m.	3,862	219	118	−25	− 475	4,025	4,054	+ 29	+ .7
25–26, 7 a. m. to 7 a. m.	3,862	219	132	−64	− 813	4,388	4,288	−100	−2.3
Total, 4 days	15,448	876	533	−68	−1,496	16,603	15,726	+123	.....
Average, 1 day	3,862	219	133	−17	− 374	3,901	3,932	+ 31	+ .8

METABOLISM EXPERIMENT NO. 13.

Subject.—E. O., as in experiment No. 11. His weight without clothing was 70 kilograms (154 pounds).

Occupation during experiment.—Reading, writing, etc., with little muscular activity. The experiment was a so-called rest experiment, although the subject moved around rather more than in earlier and later experiments of a similar kind.

Duration.—Three days, beginning at 7 a. m. November 8, 1898. The preliminary period of the experiment began with breakfast, November 4. The subject entered the calorimeter on the evening of November 7. It was intended to continue this experiment four days, but the discovery of a leak in the ventilating air pipe beyond the point where the samples for analysis were taken necessitated discarding the results for the fourth day.

Diet.—The diet during the experiment was quite similar to that in experiment No. 11, except that it furnished 117 instead of 124 grams of protein and 2,596 instead of 3,862 calories of energy per day. The kinds and quantities of food served at each meal and the quantities of drink consumed each day were as follows:

TABLE 21.—*Diet in metabolism experiment No. 13.*

FOOD.

Food materials.	Breakfast.	Dinner.	Supper.	Total.
	Grams.	*Grams.*	*Grams.*	*Grams.*
Beef	100	135	.....	235
Butter	10	15	20	45
Milk, whole	210	.....	390	600
Milk, skimmed	.....	150	.....	150
Bread	50	100	125	275
Maize breakfast food	50	.....	.....	50
Ginger snaps	.....	.....	25	25
Sugar	20	10	10	40

DRINK.

Time.	Coffee infusion.	Water.	Time.	Coffee infusion.	Water.
	Grams.	*Grams.*		*Grams.*	*Grams.*
Breakfast	300	.....	Supper	300	.....
10.30 a. m	.....	200	10.00 p. m	.....	200
Dinner	300	.....	Total for day	900	600
3.30 p. m	.....	200			

The general routine of the experiment is indicated in the following schedule. The statistics of the diary kept by the subject are summarized in Table 23.

TABLE 22.—*Daily programme—Metabolism experiment No. 13.*

7.00 a. m	Rise, pass urine, weigh self stripped, collect drip, weigh absorbers.	3.30 p. m	Drink 200 grams water.
		6.30 p. m	Supper.
		7.00 p. m	Pass urine, collect drip, weigh absorbers.
7.45 a. m	Breakfast.		
10.30 a. m	Drink 200 grams water.	10.00 p. m	Drink 200 grams water, weigh self stripped, take cap off food aperture, retire.
1.00 p. m	Pass urine, collect drip, weigh absorbers.		
1.30 p. m	Dinner.	1.00 a. m	Pass urine.

TABLE 23.—*Summary of diary—Metabolism experiment No. 13.*

Time.	Weight of subject.		Pulse rate per minute.	Temperature.	Hygrometer readings.	
	Without clothes.	With clothes.			Dry bulb.	Wet bulb.
1898.	*Kilograms.*	*Kilograms.*		°*F.*	°*C.*	°*C.*
Nov. 8, 7.00 a. m	69.36	72.50	57	96.0	20.4	15.0
10.30 a. m	.....	.....	65	96.6	20.8	15.5
2.00 p. m	.....	.....	66	99.2	20.0	15.6
5.30 p. m	.....	.....	60	98.6	20.4	16.0
7.00 p. m	.....	.....	.....	.....	20.6	15.8
9.00 p. m	.....	.....	60	97.0	.....	.....
10.00 p. m	69.50	.....	.....	.....	.....	.....
Nov. 9, 7.00 a. m	68.59	.....	56	95.6	20.0	15.2
10.30 a. m	.....	.....	63	97.6	19.8	15.4
2.00 p. m	.....	.....	65	97.4	20.7	15.4
5.30 p. m	.....	.....	68	97.0	20.8	15.6
9.00 p. m	.....	.....	64	97.5	20.0	15.4
10.00 p. m	69.71	.....	.....	.....	.....	.....
Nov. 10, 7.00 a. m	68.91	.....	58	96.0	19.5	14.6
10.30 a. m	.....	.....	65	96.6	20.1	15.0
2.00 p. m	.....	.....	68	98.0	20.6	15.4
5.30 p. m	.....	.....	61	97.9	20.2	15.3
9.00 p. m	.....	.....	62	97.8	19.6	15.0
10.00 p. m	69.16	.....	.....	.....	.....	.....
Nov. 11, 7.00 a. m	69.00	.....	57	95.9	19.5	14.6
10.30 a. m	.....	.....	64	96.8	19.6	14.6
2.00 p. m	.....	.....	65	98.6	20.0	16.1
5.30 p. m	.....	.....	65	98.0	20.0	16.0
9.00 p. m	.....	.....	69	98.6	20.8	16.7
10.00 p. m	69.58	73.40	.....	.....	.....	.....

Detailed data of income and outgo.—The weight, composition, and heat of combustion of the food eaten and of the feces are shown in the following tables. As has already been stated, the intention was to continue the experiment four days, but the discovery of a leak in the ventilating air pipe made all results after 7 a. m. of November 12 unreliable. As the discovery of the accident was made after breakfast, it was not practicable to administer charcoal for the separation of the feces until supper on November 12. The food, however, during this day was the same in kind and amount as during the previous days of the experiment proper, and a considerable portion of the time was passed within the respiration chamber.

TABLE 24.—*Weight, composition, and heat of combustion of foods—Metabolism experiment No. 13.*

Laboratory No.	Food materials.	Weight per day.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
2962	Beef	235	166.1	59.0	4.7	.....	9.40	33.75	4.86	371
2956	Butter	45	4.5	.5	38.3	.....	.09	28.60	4.54	351
2959	Milk (whole and skimmed)	750	650.3	27.0	24.0	42.8	4.35	51.98	7.80	565
2963	Bread	275	102.3	23.6	14.0	131.7	3.79	81.10	11.91	816
2960	Maize breakfast food	50	2.9	5.6	4.1	36.5	.89	22.41	3.21	223
2961	Cookies	25	1.3	1.4	2.7	19.2	.22	11.16	1.67	112
	Sugar	40	.....	.....	.....	40.0	.....	16.84	2.59	158
	Total	1,420	927.4	117.1	87.8	270.2	18.74	245.84	36.58	2,596

TABLE 25.—*Weight, composition, and heat of combustion of feces—Metabolism experiment No. 13.*

Laboratory No.		Weight of feces.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
2965	Total, 4 days	296	206.6	27.5	24.6	20.7	4.41	44.52	6.33	500
	Average, 1 day	74	51.7	6.9	6.2	5.2	1.10	11.13	1.58	125

It has proved a difficult matter to preserve urine so that there shall be no decomposition of the urea into ammonium carbonate. About 2 cubic centimeters of commercial formalin was added to the composite sample of the urine for each day as a preservative, but owing to unavoidable delays it was, in many instances, impossible to determine the heat of combustion of daily samples until some days after the experiment closed. In experiment No. 13 the heat of combustion of the composite sample for the four days was found to be 0.081 calorie per gram fresh urine, corresponding to 677 calories for the total urine for the period. Later determinations of the heat of combustion of the daily composites gave results showing that a decomposition of the urine had been going on. This decomposition was not shown by a loss of any appreciable amount of nitrogen, the decomposition products remaining largely in solution. The heat of combustion of the urine was, however, largely reduced. This is easily understood by comparing the heat of combustion of urea with that of ammonium carbonate, the former having a heat of combustion of 2.537 calories per gram as compared with 0.75 for the latter as actually determined in one sample of commercial ammonium carbonate. In this experiment, therefore, the heat of combustion of urine for each day is computed after the same

manner[a] as the carbon, hydrogen, and water-free substance for each day; in other words, it is assumed to vary with the nitrogen and in the same relative proportion.

TABLE 26.—*Amount, specific gravity, and nitrogen of urine by six-hour periods—Metabolism experiment No. 13.*

Date.	Period.	Amount of urine.	Specific gravity.	Nitrogen content.	
1898.		*Grams.*		*Per cent.*	*Grams.*
Nov. 8	7 a. m. to 1 p. m	767.2	1.015	0.78	5.98
	1 p. m. to 7 p. m	918.0	1.012	.68	6.24
8–9	7 p. m. to 1 a. m	855.2	.....	.70	5.99
	1 a. m. to 7 a. m	175.3	1.023	1.65	2.89
	Total	2,715.7	.....	.....	21.10
	Total by composite	2,715.7	1.012	.77	20.91
	7 a. m. to 1 p. m	503.6	1.020	.91	4.58
	1 p. m. to 7 p. m	550.5	1.017	.96	5.29
9–10	7 p. m. to 1 a. m	708.2	1.012	.82	5.81
10	1 a. m. to 7 a. m	223.8	1.018	1.39	3.11
	Total	1,986.1	.....	.....	18.79
	Total by composite	1,986.1	1.013	.95	18.87
	7 a. m. to 1 p. m	524.2	1.014	.88	4.61
	1 p. m. to 7 p. m	405.5	1.022	1.27	5.15
10–11	7 p. m. to 1 a. m	647.7	1.014	.91	5.90
11	1 a. m. to 7 a. m	376.4	1.010	.79	2.97
	Total	1,953.8	.....	.....	18.63
	Total by composite	1,953.8	1.015	.95	18.56
	7 a. m. to 1 p. m	653.0	1.013	.75	4.90
	1 p. m. to 7 p. m	374.3	1.022	1.33	4.98
11–12	7 p. m. to 1 a. m	403.0	1.020	1.18	4.75
12	1 a. m. to 7 a. m	275.8	1.017	1.22	3.36
	Total	1,706.1	.....	.....	17.99
	Total by composite	1,706.1	1.016	1.05	17.91
	Total, 4 days, by periods	.....	.....	.....	76.51
	Composite, 4 days	8,361.7	.....	.90	75.26

TABLE 27.—*Daily elimination of carbon, hydrogen, water, and energy in urine—Metabolism experiment No. 13.*

Date.	Amount of urine.	Carbon.		Hydrogen.		Water.		Heat of combustion.	
								Per gram.	Total.
1898.	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*Calorie.*	*Calories.*
Nov. 8–9	2,715.7	.....	16.38	.....	4.6	.....	2,629.2	.....	187
9–10	1,986.1	.....	14.58	.....	4.1	.....	1,909.1	.....	166
10–11	1,953.8	.....	14.45	.....	4.1	.....	1,877.5	.....	165
11–12	1,706.1	.....	13.96	.....	3.9	.....	1,632.4	.....	159
Total, 4 days	8,361.7	0.71	59.37	0.20	16.7	96.28	8,048.2	0.081	677

The amounts of carbon dioxid and water of respiration and perspiration during the different periods in this experiment are shown in Tables 28–30. There was but little condensation of water upon the absorbers and no "drip."

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 69, p. 35.

TABLE 28.—*Comparison of residual amounts of carbon dioxid and water in the chamber at the beginning and end of each period, and the corresponding gain or loss—Metabolism experiment No. 18.*

Date.	End of period.	Carbon dioxid.		Water.			
		Total amount in chamber.	Gain (+) or loss (−) over preceding period.	Total amount of vapor remaining in chamber.	Gain (+) or loss (−) over preceding period.	Change in weight of absorbers, gain (+) or loss (−).	Total amount gained (+) or lost (−) during the period.
1898.		*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Nov. 8–9	7 a. m.	30.8	.....	37.6	.....	.....	.....
	1 p. m.	38.8	+ 8.0	40.3	+2.7	+35	+37.7
	7 p. m.	41.0	+ 2.2	42.8	+2.5	+45	+47.5
	1 a. m.	27.6	−13.4	43.6	+ .8	+ 2	+ 2.8
	7 a. m.	26.1	− 1.5	36.9	−6.7	+ 2	− 4.7
	Total	.....	− 4.7	.....	− .7	+84	+83.3
9–10	1 p. m.	38.3	+12.2	40.1	+3.2	+ 7	+10.2
	7 p. m.	37.1	− 1.2	41.1	+1.0	−39	−38.0
	1 a. m.	27.6	− 9.5	39.2	−1.9	−10	−11.9
	7 a. m.	28.5	+ .9	37.2	−2.0	−10	−12.0
	Total	.....	+ 2.4	.....	+ .3	−52	−51.7
10–11	1 p. m.	36.4	+ 7.9	38.6	+1.4	+48	+49.4
	7 p. m.	39.8	+ 3.4	38.8	+ .2	+12	+12.2
	1 a. m.	29.1	−10.7	38.3	− .5	−23	−23.5
	7 a. m.	29.7	+ .6	35.6	−2.7	−24	−26.7
	Total	.....	+ 1.2	.....	−1.6	+13	+11.4

TABLE 29.—*Record of carbon dioxid in ventilating air current—Metabolism experiment No. 18.*

Date.	Period.	(*a*)	Carbon dioxid.						
			In incoming air.		(*d*)	(*e*)	(*f*)	(*g*)	(*h*)
		Ventilation (number of liters of air).	(*b*) Per liter.	(*c*) Total, $a \times b$.	In outgoing air.	Total excess in outgoing air, $d-c$.	Correction for amount remaining in chamber.	Corrected amount exhaled by subject, $e+f$.	Total weight exhaled, $g \times \frac{3}{11}$.
1898.		*Liters.*	*Mg.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Nov. 8–9	7 a. m. to 1 p. m.	26,872	0.641	17.2	239.3	222.1	+ 8.0	230.1	62.7
	1 p. m. to 7 p. m.	26,795	.623	16.7	239.1	222.4	+ 2.2	224.6	61.3
	7 p. m. to 1 a. m.	27,554	.579	16.0	216.5	200.5	−13.4	187.1	51.0
	1 a. m. to 7 a. m.	27,448	.618	16.9	145.9	129.0	− 1.5	127.5	34.8
	Total	108,669	.....	66.8	840.8	774.0	− 4.7	769.3	209.8
9–10	7 a. m. to 1 p. m.	26,372	.622	16.4	215.9	199.5	+12.2	211.7	57.7
	1 p. m. to 7 p. m.	26,072	.633	16.5	216.9	200.4	− 1.2	199.2	54.3
	7 p. m. to 1 a. m.	27,920	.599	16.7	223.3	206.6	− 9.5	197.1	53.8
	1 a. m. to 7 a. m.	27,549	.559	15.4	145.8	130.4	+ .9	131.3	35.8
	Total	107,913	.....	65.0	801.9	736.9	+ 2.4	739.3	201.6
10–11	7 a. m. to 1 p. m.	27,290	.592	16.2	221.5	205.3	+ 7.9	213.2	58.1
	1 p. m. to 7 p. m.	26,362	.591	15.6	218.4	202.8	+ 3.4	206.2	56.2
	7 p. m. to 1 a. m.	28,340	.551	15.6	224.5	208.9	−10.7	198.2	54.1
	1 a. m. to 7 a. m.	26,904	.579	15.6	145.7	130.1	+ .6	130.7	35.7
	Total	108,896	.....	63.0	810.1	747.1	+ 1.2	748.3	204.1
	Total, 3 days	325,478	.....	194.8	2,452.8	2,258.0	− 1.1	2,256.9	615.5

TABLE 30.—*Record of water in ventilating air current—Metabolism experiment No. 13.*

Date.	Period.	(a) Ventilation (number of liters of air).	Water in incoming air. (b) Per liter.	(c) Total, $a \times b$.	Water in outgoing air. (d) Amount condensed in freezers.	(e) Amount not condensed in freezers.	(f) Total, $d+e$.	(g) Total excess water in outgoing air, $f-c$.	(h) Correction for water remaining in chamber.	(i) Total water of respiration and perspiration, $g+h$.
1898.		*Liters.*	*Mgs.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Nov. 8–9	7 a. m. to 1 p. m.	26,872	1.135	30.5	166.9	50.5	217.4	186.9	+37.7	224.6
	1 p. m. to 7 p. m.	26,795	1.108	29.7	164.8	44.7	209.5	179.8	+47.5	227.3
	7 p. m. to 1 a. m.	27,554	1.040	28.7	197.1	50.5	247.6	218.9	+ 2.8	221.7
	1 a. m. to 7 a. m.	27,448	.980	26.9	157.6	43.5	201.1	174.2	− 4.7	169.5
	Total.....	108,669	.....	115.8	686.4	189.2	875.6	759.8	+83.3	843.1
9–10	7 a. m. to 1 p. m.	26,372	1.015	26.7	167.8	46.5	214.3	187.6	+10.2	197.8
	1 p. m. to 7 p. m.	26,072	1.045	27.2	160.7	44.7	205.4	178.2	−38.0	140.2
	7 p. m. to 1 a. m.	27,920	1.073	30.0	181.9	50.7	232.6	202.6	−11.9	190.7
	1 a. m. to 7 a. m.	27,549	.970	26.7	165.7	41.1	206.8	180.1	−12.0	168.1
	Total.....	107,913	.....	110.6	676.1	183.0	859.1	748.5	−51.7	696.8
10–11	7 a. m. to 1 p. m.	27,290	1.013	27.6	163.1	49.0	212.1	184.5	+49.4	233.9
	1 p. m. to 7 p. m.	26,362	1.082	28.5	171.7	43.3	215.0	186.5	+12.2	198.7
	7 p. m. to 1 a. m.	28,340	1.022	29.0	183.8	51.0	234.8	205.8	−23.5	182.3
	1 a. m. to 7 a. m.	26,904	.890	23.9	152.7	38.2	190.9	167.0	−26.7	140 3
	Total.....	108,896	.....	109.0	671.3	181.5	852.8	743.8	+11.4	755.2
	Total, 3 days..	325,478	.....	335.4	2,033.8	553.7	2,587.5	2,252.1	+43.0	2,295.1

Table 31 summarizes the result of the calorimetric measurements during this experiment.

TABLE 31.—*Summary of calorimetric measurements—Metabolism experiment No. 13.*

Date.	Period.	(*a*) Heat measured in terms of C_{20}.	(*b*) Change of temperature of calorimeter.	(*c*) Capacity correction of calorimeter, $b \times 60$.	(*d*) Correction due to temperature of food and dishes.	(*e*) Water vaporized equals total amount exhaled less amount condensed in chamber.	(*f*) Heat used in vaporization of water, $e \times 0.592$.	(*g*) Total heat determined, $a+c+d+f$.
1898.		*Calories.*	*Degree.*	*Calories.*	*Calories.*	*Grams.*	*Calories.*	*Calories.*
Nov. 8–9	7 a. m. to 1 p. m....	530.2	+0.02	+1.2	− 30.3	189.6	112.2	613.3
	1 p. m. to 7 p. m....	570.7	00	0	− 43.4	182.3	108.0	635.3
	7 p. m. to 1 a. m....	461.8	− .04	−2.4	.....	219.7	130.1	589.5
	1 a. m. to 7 a. m....	293.4	+ .02	+1.2	.....	167.5	99.2	393.8
	Total.....	1,856.1	.....	.....	− 73.7	759.1	449.5	2,231.9
9–10	7 a. m. to 1 p. m....	485.8	+ .01	+ .6	− 30.8	190.8	112.5	568.1
	1 p. m. to 7 p. m....	493.5	− .01	− .6	− 43.3	179.2	106.1	555.7
	7 p. m. to 1 a. m....	454.4	− .03	−1.8	.....	200.7	118.8	571.4
	1 a. m. to 7 a. m....	308.8	+ .04	+2.4	.....	178.1	105.4	416.6
	Total.....	1,742.5	.....	+ .6	− 74.1	748.8	442.8	2,111.8
10–11	7 a. m. to 1 p. m....	485.3	+ .04	+2.4	− 29.2	185.9	110.1	568.6
	1 p. m. to 7 p. m....	496.1	− .07	−4.2	− 44.8	186.7	110.5	557.6
	7 p. m. to 1 a. m....	439.7	+ .10	+6.0	.....	205.3	121.5	567.2
	1 a. m. to 7 a. m....	320.9	− .05	−3.0	.....	164.3	97.3	415.2
	Total.....	1,742.0	.....	+1.2	− 74.0	742.2	439.4	2,108.6
	Total, 3 days.	5,340.6	.....	+1.8	−221.8	2,250.1	1,331.7	6,452.3

Balance of income and outgo of matter and energy.—The calculated income and outgo of nitrogen, carbon, hydrogen, and energy are shown in the Tables 32–35.

The subject was not as nearly in nitrogen equilibrium as in many of the previous experiments, and the loss of nitrogen on the first day of the experiment was much greater than on the 2 days following. In connection with these experiments it has become a matter of frequent observation that the elimination of nitrogen in the urine seems to be affected by numerous causes little understood. Thus in this experiment the elimination of nitrogen in the urine during the 4 days preliminary to the experiment amounted to 15.3, 14.8, 20.9, and 21.4 grams, respectively, while the nitrogen eliminated in the urine during the 3 days of the experiment proper amounted to 21.1, 18.8, and 18.6 grams, respectively. It is difficult to understand the exact cause for the large elimination of nitrogen during the 2 days preceding the experiment and the first day in the apparatus. It was doubtless due to some physiological or psychic cause, but well illustrates the large fluctuation which may occur in the excretion of nitrogen without

change of diet. It is possible that nervous excitement may affect the excretion of nitrogen and that the increased elimination of nitrogen here observed may have been due in part to an incident which produced such excitement at about this time. A recent experiment by one of us (F. G. B.), however, regarding the effect of nervous excitement on the elimination of nitrogen gave negative results. In experiment No. 13 the elimination of nitrogen on the fourth day, the day on which the experiment would have terminated had there not been an accident, was 18 grams, a smaller amount than on any of the preceding days.

TABLE 32.—*Income and outgo of nitrogen and carbon—Metabolism experiment No. 13.*

Time.	Nitrogen.				Carbon.				
	(*a*) In food.	(*b*) In feces.	(*c*) In urine.	(*d*) Gain (+) or loss (−) $a-(b+c)$.	(*e*) In food.	(*f*) In feces.	(*g*) In urine.	(*h*) In respiratory products.	(*k*) Gain (+) or loss (−) $e-(f+g+h)$.
1898.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Nov. 8–9, 7 a. m. to 7 a. m.	18.7	1.1	21.1	−3.5	245.8	11.1	16.4	209.8	+ 8.5
9–10, 7 a. m. to 7 a. m.	18.8	1.1	18.8	−1.1	245.9	11.2	14.6	201.6	+18.5
10–11, 7 a. m. to 7 a. m.	18.7	1.1	18.6	−1.0	245.8	11.1	14.4	204.1	+16.2
Total, 3 days	56.2	3.3	58.5	−5.6	737.5	33.4	45.4	615.5	+43.2
Average, 1 day	18.7	1.1	19.5	−1.9	245.8	11.1	15.1	205.2	+14.4

TABLE 33.—*Income and outgo of water and hydrogen—Metabolism experiment No. 13.*

Time.	Water.					
	(*a*) In food.	(*b*) In drink.	(*c*) In feces.	(*d*) In urine.	(*e*) In respiratory products.	(*f*) Apparent loss, $a+b-(c+d+e)$.
1898.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Nov. 8–9, 7 a. m. to 7 a. m.	927.4	1,499.2	51.7	2,629.2	843.1	−1,097.4
9–10, 7 a. m. to 7 a. m.	927.4	1,500.0	51.7	1,909.1	696.8	− 230.2
10–11, 7 a. m. to 7 a. m.	927.4	1,500.0	51.7	1,877.5	755.2	− 257.0
Total, 3 days	2,782.2	4,499.2	155.1	6,415.8	2,295.1	−1,584.6
Average, 1 day	927.4	1,499.7	51.7	2,138.6	765.0	− 528.2

Time.	Hydrogen.					
	(*g*) In food.	(*h*) In feces.	(*i*) In urine.	(*l*) Apparent gain, $g-(h+i)$.	(*m*) Loss from water, $f\div 9$.	(*n*) Total gain (+) or loss (−), $l+m$.
1898.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Nov. 8–9, 7 a. m. to 7 a. m.	36.6	1.6	4.6	+30.4	−121.9	−91.5
9–10, 7 a. m. to 7 a. m.	36.6	1.6	4.1	+30.9	− 25.6	+ 5.3
10–11, 7 a. m. to 7 a. m.	36.6	1.6	4.1	+30.9	− 28.6	+ 2.3
Total, 3 days	109.8	4.8	12.8	+92 2	−176.1	−83.9
Average, 1 day	36.6	1.6	4.3	+30.7	− 58.7	−28.0

TABLE 34.—*Gain or loss of protein ($N \times 6.25$), fat, and water—Metabolism experiment No. 13.*

Time.	(*a*) Nitrogen gained (+) or lost (−).	(*b*) Protein gained (+) or lost (−), $a \times 6.25$.	(*c*) Total carbon gained (+) or lost (−).	(*d*) Carbon in protein gained (+) or lost (−), $b \times 0.53$.	(*e*) Carbon in fat, etc., gained (+) or lost (−), $c-d$.	(*f*) Fat gained (+) or lost (−), $e \div 0.765$.
1898.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Nov. 8–9, 7 a. m. to 7 a. m.	−3.5	−21.9	+ 8.5	−11.6	+20.1	+26.3
9–10, 7 a. m. to 7 a. m.	−1.1	− 6.9	+18.5	− 3.7	+22.2	+29.0
10–11, 7 a. m. to 7 a. m.	−1.0	− 6.2	+16.2	− 3.3	+19.5	+25.5
Total, 3 days	−5.6	−35.0	+43.2	−18.6	+61.8	+80.8
Average, 1 day	−1.9	−11.7	+14.4	− 6.2	+20.6	+26.9

Time.	(*g*) Total hydrogen gained (+) or lost (−).	(*h*) Hydrogen in protein gained (+) or lost (−), $b \times 0.07$.	(*i*) Hydrogen in fat gained (+) or lost (−), $f \times 0.12$.	(*k*) Hydrogen in water, etc., gained (+) or lost (−), $g-(h+i)$.	(*l*) Water gained (+) or lost (−), $k \times 9$.
1898.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Nov. 8–9, 7 a. m. to 7 a. m.	−91.5	−1.5	+3.2	−93.2	−838.8
9–10, 7 a. m. to 7 a. m.	+ 5.3	− .5	+3.5	+ 2.3	+ 20.7
10–11, 7 a. m. to 7 a. m.	+ 2.3	− .4	+3.0	− .3	− 2.7
Total, 3 days	−83.9	−2.4	+9.7	−91.2	−820.8
Average, 1 day	−28.0	− .8	+3.2	−30.4	−273.6

TABLE 35.—*Income and outgo of energy—Metabolism experiment No. 13.*

Time.	(*a*) Heat of combustion of food eaten.	(*b*) Heat of combustion of feces.	(*c*) Heat of combustion of urine.	(*d*) Estimated heat of combustion of protein gained (+) or lost (−).	(*e*) Estimated heat of combustion of fat gained (+) or lost (−).	(*f*) Estimated energy of material oxidized in the body, $a-(b+c+d+e)$.	(*g*) Heat determined.	(*h*) Heat determined greater (+) or less (−) than estimated, $g-f$.	(*i*) Heat determined greater (+) or less (−) than estimated, $h \div f$.
1898.	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Per cent.*
Nov. 8–9, 7 a. m. to 7 a. m.	2,596	125	187	−126	+247	2,163	2,232	+ 69	+3.2
9–10, 7 a. m. to 7 a. m.	2,596	125	166	− 40	+273	2,072	2,112	+ 40	+2.0
10–11, 7 a. m. to 7 a. m.	2,596	125	165	− 35	+240	2,101	2,108	+ 7	+ .3
Total, 3 days	7,788	375	518	−201	+760	6,336	6,452	+116	.....
Average, 1 day	2,596	125	173	− 67	+253	2,112	2,151	+ 39	+1.8

METABOLISM EXPERIMENT NO. 14.

Subject.—E. O., who served as the subject in experiments Nos. 11 and 13 here reported. His weight without clothing was about 64 kilograms (141 pounds). It will be noticed that he had lost about 6 kilograms in weight between the last experiment and this one. During the intervening time he had a severe cold.

Occupation during experiment.—Reading and writing, with as little muscular and mental activity as possible. The subject was considerably more quiet during this rest experiment than during the previous one.

Duration.—Four days, beginning at 7 a. m., December 20, 1898. The preliminary period continued 3 days, beginning with breakfast, December 17, 1898. The subject entered the respiration chamber on the evening of December 19.

Diet.—The diet during the experiment was much the same as during the previous experiment, and furnished 94 grams of protein and 2,513 calories of energy per day. The kinds and quantities of food served at each meal and the quantities of drink consumed each day were as follows:

TABLE 36.—*Diet in metabolism experiment No. 14.*

FOOD.

Food materials.	Breakfast.	Dinner.	Supper.	Total.
	Grams.	*Grams.*	*Grams.*	*Grams.*
Beef	55	105	.....	160
Butter	20	25	25	70
Milk, skimmed	200	.....	250	450
Bread	95	105	110	310
Maize breakfast food	50	.....	.....	50
Ginger snaps	.....	.....	30	30
Sugar	20	20	24	64

DRINK.

Time.	Coffee infusion.	Water.	Time.	Coffee infusion.	Water.
	Grams.	*Grams.*		*Grams.*	*Grams.*
Breakfast	300	.....	Supper	300	.....
10.30 a. m	.....	200	10.00 p. m	.....	200
Dinner	300	.....	Total for day	900	600
3.50 p. m	.....	200			

The general routine of the experiment is shown in the following schedule. The statistics of the diary are summarized in Table 38.

TABLE 37.—*Daily programme—Metabolism experiment No. 14.*

7.00 a. m	Rise, pass urine, weigh self stripped, collect drip, weigh absorbers.	3.30 p. m	Drink 200 grams water.
		6.30 p. m	Supper.
		7.00 p. m	Pass urine, collect drip, weigh absorbers.
7.45 a. m	Breakfast.		
10.30 a. m	Drink 200 grams water.	10.00 p. m	Drink 200 grams water, weigh self stripped, take cap off food aperture, retire.
1.00 p. m	Pass urine, collect drip, weigh absorbers.		
1.30 p. m	Dinner.	1.00 a. m	Pass urine.

TABLE 38.—*Summary of diary—Metabolism experiment No. 14.*

Date.	Weight of subject in underclothes.	Pulse rate per minute.	Temperature.	Hygrometer readings.	
				Dry bulb.	Wet bulb.
1898.	*Kilograms.*		° *F.*	° *C.*	° *C.*
Dec. 20, 7.00 a. m	63.59	64	99.0	20.8	15.6
10.30 a. m		67	99.2	21.4	17.0
5.30 p. m		65	99.4	21.2	16.4
9.00 p. m		66	99.1	21.3	16.9
10.00 p. m	64.28				
Dec. 21, 7.00 a. m	63.59	57	98.2	21.0	16.2
10.00 a. m		61	98.6	21.4	16.4
2.00 p. m		60	98.2	21.1	16.4
5.30 p. m		62	98.6	21.3	17.1
9.00 p. m		60	98.6	21.2	16.6
10.00 p. m	63.96				
Dec. 22, 7.00 a. m	63.10	62	98.2	21.4	16.6
3.00 p. m		61	99.4	21.4	16.6
10.00 p. m	64.28	66	99.6	21.4	17.1
Dec. 23, 7.00 a. m	63.23	57	99.5	21.0	16.7
3.00 p. m		62	99.2	21.1	17.1
10.00 p. m	63.95	60	97.9	21.4	16.9
Dec. 24, 7.00 a. m	62.64	59	97.2	21.4	17.0

Detailed data of income and outgo.—The usual determinations of income and outgo of nitrogen, carbon, hydrogen, and energy were made. The quantities of nutrients in the food consumed each day and the quantities rejected in the feces are shown in Tables 39 and 40.

TABLE 39.—*Weight, composition, and heat of combustion of foods—Metabolism experiment No. 14.*

Laboratory No.	Food materials.	Weight per day.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
2967	Beef	160	105.6	44.5	6.7	.....	7.10	28.40	4.22	314
2970	Butter	70	7.4	.8	59.9	.....	.13	43.79	7.14	553
2972	Skimmed milk	450	405.9	17.1	.5	22.5	2.75	19.58	2.75	198
2968	Bread	310	129.3	24.5	8.7	143.5	3.94	84.72	12.74	840
2960	Maize breakfast food	50	2.9	5.5	4.2	36.5	.89	22.41	3.21	223
	Sugar	64	.....	.....	.....	64.0	.....	26.94	4.15	253
2969	Ginger snaps	30	1.4	2.0	2.5	23.3	.31	13.16	2.02	132
	Total	1,134	652.5	94.4	82.5	289.8	15.12	239.00	36.23	2,513

TABLE 40.—*Weight, composition, and heat of combustion of feces—Metabolism experiment No. 14.*

Laboratory No.		Weight of feces.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
2974	Total, 4 days.....	218.8	162.3	21.4	14.7	12.7	3.43	29.52	4.04	328
	Average, 1 day...	54.7	40.6	5.4	3.7	3.2	.86	7.38	1.01	82

The amount and composition of the urine during this experiment are shown in Tables 41 and 42. As usual, the urine was collected in 6-hour periods, from which composite samples were made for the whole day.

After the urine for the 6-hour periods had been analyzed for nitrogen in the usual way, the small remaining portions were, as has been the custom, discarded, although the daily composite samples and the total composite sample for 4 days were saved until all possibility of their being required for future analysis had passed. Immediately after the urine for the 6-hour periods had been discarded, it was discovered that there were certain errors in the determinations of nitrogen, which rendered the results more or less uncertain. The nitrogen was redetermined in the total composite, and the results of these redeterminations appear in Table 41. These results are used in the calculation of the outgo of nitrogen instead of the sum of those in 6-hour periods, inasmuch as the latter, although in most cases very nearly the same, are thought to be, if anything, less accurate.

The heat of combustion of the total composite sample of urine for the 4 days of this experiment was determined soon after its close, but the determinations of the daily composites were, as explained in the description of the previous experiment, unavoidably postponed so long that the urine had partially decomposed. The heat of combustion of the urine for each day in this experiment is therefore computed in the same way[a] as the carbon, hydrogen, and water-free substance. The urine was not collected after the close of the experiment.

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 69, p. 35.

TABLE 41.—*Amount, specific gravity, and nitrogen of urine by six-hour periods—Metabolism experiment No. 14.*

Date.	Period.	Amount of urine.	Specific gravity.	Nitrogen content.	
1898.		*Grams.*		*Per cent.*	*Grams.*
Dec. 20–21	7 a. m. to 1 p. m	267.6	1.028	1.98	.....
	1 p. m. to 7 p. m	315.9	1.028	1.78	.....
	7 p. m. to 1 a. m	345.8	1.023	1.49	.....
	1 a. m. to 7 a. m	161.7	1.027	1.95	.....
	Total	1,091.0	.....	.....	19.22
	Total by composite	1,091.0	1.025	1.72	18.77
21–22	7 a. m. to 1 p. m	241.7	1.023	1.59	.....
	1 p. m. to 7 p. m	426.6	1.019	1.18	.....
	7 p. m. to 1 a. m	573.1	1.013	.82	.....
	1 a. m. to 7 a. m	221.0	1.016	1.08	.....
	Total	1,462.4	.....	.....	15.96
	Total by composite	1,462.4	1.016	1.09	15.94
22–23	7 a. m. to 1 p. m	352.6	1.019	1.04	.....
	1 p. m. to 7 p. m	491.2	1.016	.98	.....
	7 p. m. to 1 a. m	590.4	1.012	.74	.....
	1 a. m. to 7 a. m	164.5	1.022	1.46	.....
	Total	1,598.7	.....	.....	15.25
	Total by composite	1,598.7	1.015	.95	15.19
23–24	7 a. m. to 1 p. m	263.5	1.022	1.19	.....
	1 p. m. to 7 p. m	497.4	1.016	.97	.....
	7 p. m. to 1 a. m	703.7	1.011	.66	.....
	1 a. m. to 7 a. m	181.3	1.022	1.34	.....
	Total	1,645.9	.....	.....	15.03
	Total by composite	1,645.9	1.024	.91	14.98
	Total of composites	5,798.0	.....	.....	64.88
	Composite, 4 days	5,798.0	.....	1.12	64.94

TABLE 42.—*Daily elimination of carbon, hydrogen, water, and energy in urine—Metabolism experiment No. 14.*

Date.	Amount of urine.	Carbon.		Hydrogen.		Water.		Heat of combustion.	
								Per gram.	Total.
1898.	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*Calorie.*	*Calories.*
Dec. 20–21	1,091.0	.....	14.09	.....	4.02	.....	1,037.3	.....	164
21–22	1,462.4	.....	11.97	.....	3.42	.....	1,416.8	.....	140
22–23	1,598.7	.....	11.40	.....	3.26	.....	1,555.3	.....	133
23–24	1,645.9	.....	11.24	.....	3.21	.....	1,603.1	.....	131
Total, 4 days	5,798.0	0.84	48.70	0.24	13.91	96.08	5,612.5	0.098	568

The amounts of carbon dioxid and water given off in respiration and perspiration during the experiment are shown in Tables 43–45.

TABLE 43.—*Comparison of residual amounts of carbon dioxid and water in the chamber at the beginning and end of each period, and the corresponding gain or loss—Metabolism experiment No. 14.*

Date.	End of period.	Carbon dioxid.		Water.			
		Total amount in chamber.	Gain (+) or loss (−) over preceding period.	Total amount of vapor remaining in chamber.	Gain (+) or loss (−) over preceding period.	Change in weight of absorbers, gain (+) or loss (−).	Total amount gained (+) or lost (−) during the period.
1898.		*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Dec. 20–21	7 a. m.	30.6		40.3			
	1 p. m.	38.0	+ 7.4	46.0	+ 5.7	−10	− 4.3
	7 p. m.	35.2	− 2.8	44.7	− 1.3	+19	+17.7
	1 a. m.	27.1	− 8.1	49.5	+ 4.8	− 8	− 3.2
	7 a. m.	24.0	− 3.1	39.4	−10.1	− 7	−17.1
	Total		− 6.6		− .9	− 6	− 6.9
21–22	1 p. m.	33.4	+ 9.4	39.8	+ .4	− 2	− 1.6
	7 p. m.	35.5	+ 2.1	46.7	+ 6.9	+ 7	+13.9
	1 a. m.	27.9	− 7.6	45.4	− 1.3	− 1	− 2.3
	7 a. m.	27.0	− .9	42.3	− 3.1	0	− 3.1
	Total		+ 3.0		+ 2.9	+ 4	+ 6.9
22–23	1 p. m.	37.7	+10.7	44.2	+ 1.9	− 8	− 6.1
	7 p. m.	41.6	+ 3.9	48.2	+ 4.0	+22	+26.0
	1 a. m.	37.1	− 4.5	53.2	+ 5.0	− 3	+ 2.0
	7 a. m.	28.9	− 8.2	45.8	− 7.4	− 3	−10.4
	Total		+ 1.9		+ 3.5	+ 8	+11.5
23–24	1 p. m.	37.4	+ 8.5	44.5	− 1.3	−16	−17.3
	7 p. m.	37.6	+ .2	45.9	+ 1.4	+ 8	+ 9.4
	1 a. m.	27.5	−10.1	50.9	+ 5.0	+ 5	+10.0
	7 a. m.	23.8	− 3.7	46.4	− 4.5	+ 3	− 1.5
	Total		− 5.1		+ .6		+ .6

TABLE 44.—*Record of carbon dioxid in ventilating air current—Metabolism experiment No. 14.*

Date.	Period.	(a) Ventilation (number of liters of air).	Carbon dioxid. In incoming air. (b) Per liter.	(c) Total, $a \times b$.	(d) In outgoing air.	(e) Total excess in outgoing air, $d-c$.	(f) Correction for amount remaining in chamber.	(g) Corrected amount exhaled by subject, $e+f$.	(h) Total weight of carbon exhaled, $g \times \frac{11}{3}$.
1898.		*Liters.*	*Mg.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Dec. 20–21	7 a. m. to 1 p. m.	26,170	0.634	16.6	221.6	205.0	+ 7.4	212.4	57.9
	1 p. m. to 7 p. m.	26,608	.566	15.1	225.6	210.5	− 2.8	207.7	56.7
	7 p. m. to 1 a. m.	27,430	.555	15.2	226.5	211.3	− 8.1	203.2	55.4
	1 a. m. to 7 a. m.	27,525	.591	16.3	161.7	145.4	− 3.1	142.3	38.8
	Total	107,733	.....	63.2	835.4	772.2	− 6.6	765.6	208.8
21–22	7 a. m. to 1 p. m.	26,971	.598	16.1	217.0	200.9	+ 9.4	210.3	57.4
	1 p. m. to 7 p. m.	26,507	.597	15.8	218.6	202.8	+ 2.1	204.9	55.9
	7 p. m. to 1 a. m.	27,130	.571	15.5	214.5	199.0	− 7.6	191.4	52.2
	1 a. m. to 7 a. m.	26,989	.576	15.5	154.2	138.7	− .9	137.8	37.6
	Total	107,597	.....	62.9	804.3	741.4	+ 3.0	744.4	203.1
22–23	7 a. m. to 1 p. m.	26,093	.595	15.5	219.8	204.3	+10.7	215.0	58.6
	1 p. m. to 7 p. m.	27,152	.615	16.7	220.7	204.0	+ 3.9	207.9	56.7
	7 p. m. to 1 a. m.	27,485	.616	16.9	229.6	212.7	− 4.5	208.2	56.8
	1 a. m. to 7 a. m.	27,580	.639	17.6	157.9	140.3	− 8.2	132.1	36.0
	Total	108,310	.....	66.7	828.0	761.3	+ 1.9	763.2	208.1
23–24	7 a. m. to 1 p. m.	26,971	.625	16.8	224.5	207.7	+ 8.5	216.2	58.9
	1 p. m. to 7 p. m.	27,059	.577	15.6	232.1	216.5	+ .2	216.7	59.1
	7 p. m. to 1 a. m.	27,818	.552	15.3	227.8	212.5	−10.1	202.4	55.2
	1 a. m. to 7 a. m.	27,533	.576	15.8	151.0	135.2	− 3.7	131.5	35.9
	Total	109,381	.....	63.5	835.4	771.9	− 5.1	766.8	209.1
	Total, 4 days	433,021	.....	256.3	3,303.1	3,046.8	− 6.8	3,040.0	829.1

TABLE 45.—*Record of water in ventilating air current—Metabolism experiment No. 14.*

Date.	Period.	(a) Ventilation (number of liters of air).	Water in incoming air. (b) Per liter.	Water in incoming air. (c) Total, $a \times b$.	Water in outgoing air. (d) Amount condensed in freezers.	Water in outgoing air. (e) Amount not condensed in freezers.	Water in outgoing air. (f) Total, $d+e$.	(g) Total excess water in outgoing air, $f-c$.	(h) Correction of water remaining in chamber.	(i) Total water of respiration and perspiration, $g+h$.
1898.		*Liters.*	*Mgs.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Dec. 20–21	7 a. m. to 1 p. m.	26,170	1,023	26.8	195.1	46.6	241.7	214.9	− 4.3	210.6
	1 p. m. to 7 p. m.	26,608	.888	23.6	219.9	41.6	261.5	237.9	+17.7	255.6
	7 p. m. to 1 a. m.	27,430	.853	23.4	229.8	45.1	274.9	251.5	− 3.2	248.3
	1 a. m. to 7 a. m.	27,525	.870	24.0	222.2	41.1	263.3	239.3	−17.1	222.2
	Total.....	107,733	.....	97.8	867.0	174.4	1,041.4	943.6	− 6.9	936.7
21–22	7 a. m. to 1 p. m.	26,971	.868	23.4	203.5	40.7	244.2	220.8	− 1.6	219.2
	1 p. m. to 7 p. m.	26,507	.882	23.4	222.4	40.4	262.8	239.4	+13.9	253.3
	7 p. m. to 1 a. m.	27,130	.886	24.0	220.1	45.4	265.5	241.5	− 2.3	239.2
	1 a. m. to 7 a. m.	26,989	.894	24.1	215.7	39.6	255.3	231.2	− 3.1	228.1
	Total.....	107,597	.....	94.9	861.7	166.1	1,027.8	932.9	+ 6.9	939.8
22–23	7 a. m. to 1 p. m.	26,093	.884	23.1	203.5	39.0	242.5	219.4	− 6.1	213.3
	1 p. m. to 7 p. m.	27,152	.930	25.3	220.1	42.2	262.3	237.0	+26.0	263.0
	7 p. m. to 1 a. m.	27,485	.952	26.2	241.9	47.1	289.0	262.8	+ 2.0	264.8
	1 a. m. to 7 a. m.	27,580	.871	24.0	224.4	41.7	266.1	242.1	−10.4	231.7
	Total.....	108,310	.....	98.6	889.9	170.0	1,059.9	961.3	+11.5	972.8
23–24	7 a. m. to 1 p. m.	26,971	.942	25.4	216.2	43.9	260.1	234.7	−17.3	217.4
	1 p. m. to 7 p. m.	27,059	.927	25.1	235.6	41.5	277.1	252.0	+ 9.4	261.4
	7 p. m. to 1 a. m.	27,818	.874	24.3	235.6	46.5	282.1	257.8	+10.0	267.8
	1 a. m. to 7 a. m.	27,533	.886	24.4	239.6	41.4	281.0	256.6	− 1.5	255.1
	Total.....	109,381	.....	99.2	927.0	173.3	1,100.3	1,001.1	+ .6	1,001.7
	Total, 4 days..	433,021	.....	390.5	3,545.6	683.8	4,229.4	3,838.9	+12.1	3,851.0

Table 46 summarizes the heat measurements during this experiment.

TABLE 46.—*Summary of calorimetric measurements—Metabolism experiment No 14.*

Date.	Period.	(*a*) Heat measured in terms of C_{20}.	(*b*) Change of temperature of calorimeter.	(*c*) Capacity correction of calorimeter, $b \times 60$.	(*d*) Correction due to temperature of food and dishes.	(*e*) Water vaporized equals total amount exhaled less amount condensed in chamber.	(*f*) Heat used in vaporization of water, $e \times 0.592$.	(*g*) Total heat determined, $a+c+d+f$.
1898.		*Calories.*	*Degree.*	*Calories.*	*Calories.*	*Grams.*	*Calories.*	*Calories.*
Dec. 20–21	7 a. m. to 1 p. m...	546.0	+0.06	+3.6	− 20.3	220.6	130.6	659.9
	1 p. m. to 7 p. m...	509.9	+ .05	+3.0	− 43.3	236.6	140.1	609.7
	7 p. m. to 1 a. m...	444.3	00	0	.....	256.3	151.7	596.0
	1 a. m. to 7 a. m...	328.3	+ .05	+3.0	.....	229.2	135.7	467.0
	Total.....	1,828.5	.....	+9.6	− 63.6	942.7	558.1	2,332.6
21–22	7 a. m. to 1 p. m...	466.5	− .02	−1.2	− 24.3	221.2	131.0	572.0
	1 p. m. to 7 p. m...	478.3	− 04	−2.4	− 42.3	246.3	145.8	579.4
	7 p. m. to 1 a. m...	364.4	− .05	−3.0	.....	240.2	142.2	503.6
	1 a. m. to 7 a. m...	271.5	00	0	.....	228.1	135.1	406.6
	Total.....	1,580.7	.....	−6.6	− 66.6	935.8	554.1	2,061.6
22–23	7 a. m. to 1 p. m...	458.3	+ .05	+3.0	− 21.8	221.3	131.0	570.5
	1 p. m. to 7 p. m...	502.5	− .05	−3.0	− 37.3	241.0	142.7	604.9
	7 p. m. to 1 a. m...	408.9	+ .05	+3.0	.....	267.8	158.5	570.4
	1 a. m. to 7 a. m...	297.0	− .05	−3.0	.....	234.7	139.0	433.0
	Total.....	1,666.7	.....	.....	− 59.1	964.8	571.2	2,178.8
23–24	7 a. m. to 1 p. m...	503.7	+ .02	+1.2	− 25.4	233.4	138.2	617.7
	1 p. m. to 7 p. m...	514.6	00	0	− 41.4	253.4	150.0	623.2
	7 p. m. to 1 a. m...	403.0	+ .04	+2.4	.....	262.8	155.6	561.0
	1 a. m. to 7 a. m...	247.7	00	0	.....	252.1	149.3	397.0
	Total.....	1,669.0	.....	+3.6	− 66.8	1,001.7	593.1	2,198.9
	Total, 4 days	6,744.9	.....	+6.6	−256.1	3,845.0	2,276.5	8,771.9

Balance of income and outgo of matter and energy.—Tables 47–50 show the income and outgo of nitrogen, carbon, hydrogen, and energy in this experiment, and the average for 4 days.

TABLE 47.—*Income and outgo of nitrogen and carbon—Metabolism experiment No. 14.*

Time.	Nitrogen.				Carbon.				
	(*a*) In food.	(*b*) In feces.	(*c*) In urine.	(*d*) Gain (+) or loss (−) *a*−(*b*+*c*).	(*e*) In food.	(*f*) In feces.	(*g*) In urine.	(*h*) In respiratory products.	(*k*) Gain (+) or loss (−) *e*−(*f*+*g*+*h*).
1898.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Dec. 20–21, 7 a. m. to 7 a. m.	15.1	0.9	18.8	−4.6	239.0	7.4	14.1	208.8	+ 8.7
21–22, 7 a. m. to 7 a. m.	15.1	.8	15.9	−1.6	239.0	7.4	12.0	203.1	+16.5
22–23, 7 a. m. to 7 a. m.	15.1	.9	15.2	−1.0	239.0	7.4	11.4	208.1	+12.1
23–24, 7 a. m. to 7 a. m.	15.1	.8	15.0	− .7	239.0	7.4	11.2	209.1	+11.3
Total, 4 days	60.4	3.4	64.9	−7.9	956.0	29.6	48.7	829.1	+48.6
Average, 1 day	15.1	.9	16.2	−2.0	239.0	7.4	12.2	207.3	+12.1

TABLE 48.—*Income and outgo of water and hydrogen—Metabolism experiment No. 14.*

Time.	Water.					
	(*a*) In food.	(*b*) In drink.	(*c*) In feces.	(*d*) In urine.	(*e*) In respiratory products.	(*f*) Apparent loss, *a*+*b*−(*c*+*d*+*e*).
1898.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Dec. 20–21, 7 a. m. to 7 a. m.	652.5	1,500	40.6	1,037.3	936.7	+ 137.9
21–22, 7 a. m. to 7 a. m.	652.5	1,500	40.6	1,416.8	939.8	− 244.7
22–23, 7 a. m. to 7 a. m.	652.5	1,500	40.6	1,555.3	972.8	− 416.2
23–24, 7 a. m. to 7 a. m.	652.5	1,500	40.6	1,603.1	1,001.7	− 492.9
Total, 4 days	2,610.0	6,000	162.4	5,612.5	3,851.0	−1,015.9
Average, 1 day	652.5	1,500	40.6	1,403.1	962.8	− 254.0

Time.	Hydrogen.					
	(*g*) In food.	(*h*) In feces.	(*i*) In urine.	(*l*) Apparent gain, *g*−(*h*+*i*).	(*m*) Loss from water, *f*÷9.	(*n*) Total gain (+) or loss (−), *l*+*m*.
1898.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Dec. 20–21, 7 a. m. to 7 a. m.	36.2	1.0	4.1	31.1	+ 15.3	+16.4
21–22, 7 a. m. to 7 a. m.	36.2	1.0	3.4	31.8	− 27.2	+ 4.6
22–23, 7 a. m. to 7 a. m.	36.2	1.0	3.2	32.0	− 46.2	−14.2
23–24, 7 a. m. to 7 a. m.	36.2	1.0	3.2	32.0	− 54.8	−22.8
Total, 4 days	144.8	4.0	13.9	126.9	−112.9	+14.0
Average, 1 day	36.2	1.0	3.5	31.7	− 28.2	+ 3.5

TABLE 49.—*Gain or loss of protein ($N \times 6.25$), fat, and water—Metabolism experiment No. 14.*

Time.	(*a*) Nitrogen gained (+) or lost (−).	(*b*) Protein gained (+) or lost (−), $a \times 6.25$.	(*c*) Total carbon gained (+) or lost (−).	(*d*) Carbon in protein gained (+) or lost (−), $b \times 0.53$.	(*e*) Carbon in fat, etc., gained (+) or lost (−), $c - d$.	(*f*) Fat gained (+) or lost (−), $e \div 0.765$.
1898.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Dec. 20–21, 7 a. m. to 7 a. m	−4.6	−28.7	+8.7	−15.2	+23.9	+31.2
21–22, 7 a. m. to 7 a. m	−1.6	−10.0	+16.5	−5.3	−21.8	+28.5
22–23, 7 a. m. to 7 a. m	−1.0	−6.3	+12.1	−3.3	+15.4	+20.1
23–24, 7 a. m. to 7 a. m	−.7	−4.4	+11.3	−2.3	+13.6	+17.8
Total, 4 days	−7.9	−49.4	+48.6	−26.1	+74.7	+97.6
Average, 1 day	−2.0	−12.4	+12.1	−6.5	+18.6	+24.4

Time.	(*g*) Total hydrogen gained (+) or lost (−).	(*h*) Hydrogen in protein gained (+) or lost (−), $b \times 0.07$.	(*i*) Hydrogen in fat gained (+) or lost (−), $f \div 0.12$.	(*k*) Hyrogen in water, etc., gained (+) or lost (−), $g - (h + i)$.	(*l*) Water gained (+) or lost (−), $k \times 9$.
1898.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Dec. 20–21, 7 a. m. to 7 a. m	+46.4	−2.0	+3.8	+44.6	+401
21–22, 7 a. m. to 7 a. m	+4.6	−.7	+3.4	+1.9	+17
22–23, 7 a. m. to 7 a. m	−14.2	−.4	+2.4	−16.2	−146
23–24, 7 a. m. to 7 a. m	−22.8	−.3	+2.1	−24.6	−221
Total, 4 days	+14.0	−3.4	+11.7	+5.7	+51
Average, 1 day	+3.5	−.8	+2.9	+1.4	+13

TABLE 50.—*Income and outgo of energy—Metabolism experiment No. 14.*

Time.	(*a*) Heat of combustion of food eaten.	(*b*) Heat of combustion of feces.	(*c*) Heat of combustion of urine.	(*d*) Estimated heat of combustion of protein gained (+) or lost (−).	(*e*) Estimated heat of combustion of fat gained (+) or lost (−).	(*f*) Estimated energy of material oxidized in the body, $a - (b + c + d + e)$.	(*g*) Heat determined.	(*h*) Heat determined greater (+) or less (−) than estimated, $g - f$.	(*i*) Heat determined greater (+) or less (−) than estimated, $h \div f$.
1898.	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Per cent.*
Dec. 20–21, 7 a. m. to 7 a. m.	2,513	82	164	−165	+293	2,139	2,333	+194	+9.1
21–22, 7 a. m. to 7 a. m.	2,513	82	140	−58	+268	2,081	2,061	−20	−1.0
22–23, 7 a. m. to 7 a. m.	2,513	82	133	−36	+189	2,145	2,179	+34	+1.6
23–24, 7 a. m. to 7 a. m.	2,513	82	131	−25	+167	2,158	2,199	+41	+1.9
Total, 4 days	10,052	328	568	−284	+917	8,523	8,772	+249	.....
Average, 1 day	2,513	82	142	−71	+229	2,131	2,193	+62	+2.9

METABOLISM EXPERIMENT NO. 21.

Subject.—A. W. S., a physicist, who served as the subject of experiment No. 4, made before the respiration apparatus had been perfected as a calorimeter.[a] He was 25 years of age and averaged about 70 kilograms (154 pounds) in weight.

Occupation during experiment.—Reading, writing, etc., with as little muscular activity as practicable.

Duration.—Three days, beginning at 7 a. m. February 12, 1899.

Diet.—The diet consisted of beef, butter, whole milk, bread, parched cereal, and sugar, and furnished 97 grams of protein and 2,264 calories of energy per day. The kinds and quantities of food served at each meal and the quantities of drink at different periods of the day were as follows:

TABLE 51.—*Diet in metabolism experiment No. 21.*

FOOD.

Food materials.	Breakfast.	Dinner.	Supper.	Total.
	Grams.	*Grams.*	*Grams.*	*Grams.*
Beef	55	105	.....	160
Butter	7	10	13	30
Milk, whole	250	175	325	750
Bread	55	100	155	310
Parched cereal	30	.....	.....	30
Sugar	45	.....	.....	45

DRINK.

Time.	Water.	Time.	Water.
	Grams.		*Grams.*
Breakfast	300	Supper	300
10.00 a. m	200	10.30 p. m	200
Dinner	300	Total for day	1,500
3.30	200		

The general routine of the experiment is indicated in the following schedule. The statistics of the diary kept by the subject are summarized in Table 53, below:

TABLE 52.—*Daily programme—Metabolism experiment No. 21.*

7.00 a. m	Rise, pass urine, weigh self stripped and dressed, weigh absorbers.	1.15 p. m	Dinner.
		6.00 p. m	Supper.
		7.00 p. m	Pass urine.
7.45 a. m	Breakfast, drink 200 grams water.	10.30 p. m	Pass urine, weigh self stripped, take cap off food aperture, retire.
1.00 p. m	Pass urine.		

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 44, p. 51.

TABLE 53.—*Summary of diary—Metabolism experiment No. 21.*

Time.	Weight of subject without clothes.	Pulse rate per minute.	Temperature.	Hygrometer readings.	
				Dry bulb.	Wet bulb.
1899.	*Kilograms.*		°*F.*	°*C.*	°*C.*
Feb. 12, 7.00 a. m	69.48	70	97.8	19.80	15.15
12.43 p. m				19.90	15.20
6.45 p. m				19.70	15.40
10.00 p. m	69.80	64	97.1	19.75	15.00
Feb. 13, 7.00 a. m	69.35	74	97.5	20.00	14.90
12.45 p. m				19.80	15.30
6.50 p. m				19.70	15.10
10.05 p. m	69.84	61	97.1	19.80	15.40
Feb. 14, 7.00 a. m	69.34	70	97.0	20.00	15.00
12.45 p. m				19.65	15.50
7.25 p. m				19.80	15.80
10.00 p. m	69.43	67	98.0	19.70	15.80
Feb. 15, 7.00 a. m	69.05	72	97.4	20.30	15.70

Detailed data of income and outgo.—The usual statistics of income and outgo of matter and energy are shown in Tables 54–61, which follow.

Experiments not reported here, covering 10 consecutive days, preceded experiment No. 21. During this time the bowels were slightly lax. This prevented separation of the feces for the preliminary days from those for experiment No. 21. The total feces for 13 days are therefore recorded, as well as the average per day for this experiment.

TABLE 54.—*Weight, composition, and heat of combustion of foods—Metabolism experiment No. 21.*

Laboratory No.	Food materials.	Weight per day.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
3022	Beef	160	106.7	44.6	4.2	.....	7.14	26.51	4.06	292
3020	Butter	30	2.6	.4	26.3	.....	.06	19.87	3.16	245
3024	Milk, whole	750	649.5	24.0	33.0	37.5	3.83	52.72	7.05	587
2968	Bread	310	129.3	24.5	8.7	143.5	3.94	84.72	12.74	840
3004	Cereal, parched	30	1.8	3.4	.2	24.1	.55	12.42	1.85	122
	Sugar	45	.....	.....	.....	45.0	.....	18.95	2.92	178
	Total	1,325	889.9	96.9	72.4	250.1	15.52	215.19	31.78	2,264

TABLE 55.—*Weight, composition, and heat of combustion of feces—Metabolism experiment No. 21.*

Laboratory No.		Weight of feces.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
3033	Total, 13 days[a] ...	831.7	603.8	84.0	52.4	52.4	13.47	116.69	16.13	1,307
	Average, 1 day...	63.9	46.4	6.5	4.0	4.0	1.04	8.98	1.24	100

[a] This period includes the 3 days of the experiment and 10 days of a preliminary experiment not reported herewith.

The elimination of nitrogen in the urine during this experiment is summarized in Table 56, which also gives the details of the total amount of urine and its nitrogen content in each 6-hour period. The daily elimination of carbon, hydrogen, water, and energy in the urine is shown in Table 57.

TABLE 56.—*Amount, specific gravity, and nitrogen of urine by six-hour periods—Metabolism experiment No. 21.*

Date.	Period.	Amount of urine.	Specific gravity.	Nitrogen content.	
1899.		*Grams.*		*Per cent.*	*Grams.*
Feb. 12–13	7 a. m. to 1 p. m	435.7	1.015	0.93	4.05
	1 p. m. to 7 p. m	806.8	1.009	.58	4.68
	7 p. m. to 1 a. m	224.0	1.015	.91	2.04
	1 a. m. to 7 a. m	214.4	1.017	1.74	3.73
	Total	1,680.9			14.50
	Total by composite	1,680.9	1.014	.87	14.62
13–14	7 a. m. to 1 p. m	588.9	1.015	.86	5.06
	1 p. m. to 7 p. m	536.8	1.014	.87	4.67
	7 p. m. to 1 a. m	398.9	1.010	.62	2.42
	1 a. m. to 7 a. m	223.5	1.026	1.79	4.00
	Total	1,748.1			16.15
	Total by composite	1,748.1	1.015	.94	16.43
14–15	7 a. m. to 1 p. m	637.5	1.010	.67	4.27
	1 p. m. to 7 p. m	656.6	1.012	.74	4.86
	7 p. m. to 1 a. m	441.5	1.009	.55	2.43
	1 a. m. to 7 a. m	229.7	1.025	1.69	3.88
	Total	1,965.3			15.44
	Total by composite	1,965.3	1.012	.79	15.53
12–14	Total, 3 days, by periods	5,394.3			46.09
12–14	Total by composite	5,394.3	1.013	.85	46.15

TABLE 57.—*Daily elimination of carbon, hydrogen, water, and energy in urine—Metabolism experiment No. 21.*

Date.	Amount of urine.	Carbon.		Hydrogen.		Water.		Heat of combustion.	
								Per gram.	Total.
1899.	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*Calorie.*	*Calories.*
Feb. 12–13	1,689.9	.....	10.18	.....	2.89	.....	1,628.3	.....	119
13–14	1,748.1	.....	11.34	.....	3.21	.....	1,689.5	.....	132
14–15	1,965.3	.....	10.85	.....	3.07	.....	1.909.3	.....	127
Total, 3 days	5,394.3	0.60	32.37	0.17	9.17	96.9	5,227.1	0.070	378

The details of the measurements of carbon dioxid and water in the ventilating air current are shown in Tables 58–60, which follow.

TABLE 58.—*Comparison of residual amounts of carbon dioxid and water in the chamber at the beginning and end of each period, and the corresponding gain or loss—Metabolism experiment No. 21.*

Date.	End of period.	Carbon dioxid.		Water.			
		Total amount in chamber.	Gain (+) or loss (−) over preceding period.	Total amount of vapor remaining in chamber.	Gain (+) or loss (−) over preceding period.	Change in weight of absorbers, gain (+) or loss (−).	Total amount gained (+) or lost (−) during the period.
1899.		*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Feb. 12–13	7 a. m.	32.7	.....	38.1	.....	.....	.....
	1 p. m.	37.4	+ 4.7	38.6	+ .5	.....	+ .5
	7 p. m.	42.5	+ 5.1	40.3	+ 1.7	.....	+ 1.7
	1 a. m.	29.1	−13.4	38.6	− 1.7	.....	− 1.7
	7 a. m.	27.4	− 1.7	35.0	− 3.6	.....	− 3.6
	Total	.....	− 5.3	.....	− 3.1	.....	− 3.1
13–14	1 p. m.	38.5	+11.1	41.6	+ 6.6	−1	+ 5.6
	7 p. m.	45.8	+ 7.3	43.3	+ 1.7	−1	+ .7
	1 a. m.	33.9	−11.9	41.0	− 2.3	.....	− 2.3
	7 a. m.	28.7	− 5.2	35.0	− 6.0	.....	− 6.0
	Total	.....	+ 1.3	.....	0	−2	− 2.0
14–15	1 p. m.	46.7	+18.0	45.0	+10.0	+1	+11.0
	7 p. m.	44.0	− 2.7	44.9	− .1	.....	− .1
	1 a. m.	29.3	−14.7	41.6	− 3.3	.....	− 3.3
	7 a. m.	25.7	− 3.6	35.7	− 5.9	.....	− 5.9
	Total	.....	− 3.0	.....	+ .7	+1	+ 1.7

TABLE 59.—*Record of carbon dioxid in ventilating air current—Metabolism experiment No. 21.*

Date.	Period.	(*a*) Ventilation (number of liters of air).	Carbon dioxid. In incoming air. (*b*) Per liter.	(*c*) Total, $a \times b$.	(*d*) In outgoing air.	(*e*) Total excess in outgoing air, $d-c$.	(*f*) Correction for amount remaining in chamber	(*g*) Corrected amount exhaled by subject, $e+f$.	(*h*) Total weight of carbon exhaled, $g \times \frac{3}{11}$.
1899.		*Liters.*	*Mgs.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Feb. 12-13	7 a. m. to 1 p. m..	26,528	0.580	15.4	239.3	223.9	+ 4.7	228.6	62.3
	1 p. m. to 7 p. m..	26,608	.595	15.8	239.7	223.9	+ 5.1	229.0	62.5
	7 p. m. to 1 a. m..	27,896	.574	16.0	214.9	198.9	−13.4	185.5	50.6
	1 a. m. to 7 a. m..	28,031	.554	15.5	163.2	147.7	− 1.7	146.0	39.8
	Total	109,063	.....	62.7	857.1	794.4	− 5.3	789.1	215.2
13-14	7 a. m. to 1 p. m..	26,505	.569	15.1	243.2	228.1	+11.1	239.2	65.2
	1 p. m. to 7 p. m..	26,079	.589	15.3	223.2	207.9	+ 7.3	215.2	58.7
	7 p. m. to 1 a. m..	28,410	1.046	29.7	243.2	213.5	−11.9	201.6	55.0
	1 a. m. to 7 a. m..	28,070	2.430	68.2	204.3	136.1	− 5.2	130.9	35.7
	Total	109,064	.....	128.3	913.9	785.6	+ 1.3	786.9	214.6
14-15	7 a. m. to 1 p. m..	26,652	.608	16.2	246.9	230.7	+18.0	248.7	67.8
	1 p. m. to 7 p. m..	26,204	.600	15.7	241.7	226.0	− 2.7	223.3	60.9
	7 p. m. to 1 a. m..	27,251	.579	15.8	232.9	217.1	−14.7	202.4	55.2
	1 a. m. to 7 a. m..	27,875	.629	17.5	162.7	145.2	− 3.6	141.6	38.6
	Total	107,982	.....	65.2	884.2	819.0	− 3.0	816.0	222.5
	Total, 3 days..	326,109	.....	256.2	2,655.2	2,399.0	− 7.0	2,392.0	652.3

TABLE 60.—*Record of water in ventilating air current—Metabolism experiment No. 21.*

Date.	Period.	(*a*) Ventilation (number of liters of air).	Water in incoming air. (*b*) Per liter.	(*c*) Total, $a \times b$.	Water in outgoing air. (*d*) Amount condensed in freezers.	(*e*) Amount not condensed in freezers.	(*f*) Total, $d+e$.	(*g*) Total excess water in outgoing air, $f-c$.	(*h*) Correction for water remaining in chamber.	(*i*) Total water of respiration and perspiration, $g+h$.
1899.		*Liters.*	*Mg.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Feb. 12-13	7 a. m. to 1 p. m..	26,528	0.740	19.6	194.5	34.8	229.3	209.7	+ 0.5	210.2
	1 p. m. to 7 p. m..	26,608	.756	20.1	193.0	36.8	229.8	209.7	+ 1.7	211.4
	7 p. m. to 1 a. m..	27,896	.758	21.2	188.0	43.7	231.7	210.5	− 1.7	208.8
	1 a. m. to 7 a. m..	28,031	.721	20.2	179.9	34.8	214.7	194.5	− 3.6	190.9
	Total	109,063	.....	81.1	755.4	150.1	905.5	824.4	− 3.1	821.3
13-14	7 a. m. to 1 p. m..	26,505	.739	19.6	195.9	36.1	232.0	212.4	+ 5.6	218.0
	1 p. m. to 7 p. m..	26,079	.749	19.5	198.4	33.8	232.2	212.7	+ .7	213.4
	7 p. m. to 1 a. m..	28,410	.775	22.0	208.9	43.6	252.5	230.5	− 2.3	228.2
	1 a. m. to 7 a. m..	28,070	.848	23.8	192.7	35.9	228.6	204.8	− 6.0	198.8
	Total	109,064	.....	84.9	795.9	149.4	945.3	860.4	− 2.0	858.4
14-15	7 a. m. to 1 p. m..	26,652	.797	21.3	199.5	35.6	235.1	213.8	+11.0	224.8
	1 p. m. to 7 p. m..	26,204	.804	21.1	213.9	34.9	248.8	227.7	− .1	227.6
	7 p. m. to 1 a. m..	27,251	.766	20.9	219.3	40.9	260.2	239.3	− 3.3	236.0
	1 a. m. to 7 a. m..	27,875	.754	21.0	200.8	35.3	236.1	215.1	− 5.9	209.2
	Total	107,982	.....	84.3	833.5	146.7	980.2	895.9	+ 1.7	897.6
	Total, 3 days..	326,109	.....	250.3	2,384.8	446.2	2,831.0	2,580.7	− 3.4	2,577.3

Table 61 shows the amount of heat carried away in the water current and in the water vapor in successive 6-hour periods.

TABLE 61.—*Summary of calorimetric measurements—Metabolism experiment No. 21.*

Date.	Period.	(*a*) Heat measure in terms of C_{20}.	(*b*) Change of temperature of calorimeter.	(*c*) Capacity correction of calorimeter, $b \times 60$.	(*d*) Correction due to temperature of food and dishes.	(*e*) Water vaporized equals total amount exhaled less amount condensed in chamber.	(*f*) Heat used in vaporization of water, $e \times 0.592$.	(*g*) Total heat determined, $a+c+d+f$.
1899.		*Calories.*	*Degree.*	*Calories.*	*Calories.*	*Grams.*	*Calories.*	*Calories.*
Feb. 12–13	7 a. m. to 1 p. m..	531.5	+0.02	+1.2	+12.7	210.2	124.4	669.8
	1 p. m. to 7 p. m..	495.2	- .02	−1.2	+ 9.7	211.4	125.2	628.9
	7 p. m. to 1 a. m..	427.3	+ .01	+ .6	.....	208.8	123.6	551.5
	1 a. m. to 7 a. m..	264.8	− .03	−1.8	.....	190.9	113.0	376.0
	Total.....	1,718.8	− .02	−1.2	+22.4	821.3	486.2	2,226.2
13–14	7 a. m. to 1 p. m..	534.9	.....	.....	+ 8.8	219.0	129.7	673.4
	1 p. m. to 7 p. m..	473.2	+ .02	+1.2	+ 8.1	214.4	126.9	609.4
	7 p. m. to 1 a. m..	427.7	− .01	- .6	.....	228.2	135.1	562.2
	1 a. m. to 7 a. m..	301.6	− .03	−1.8	.....	198.8	117.7	417.5
	Total.....	1,737.4	-- .02	−1.2	+16.9	860.4	509.4	2,262.5
14–15	7 a. m. to 1 p. m..	583.4	− .03	−1.8	+ 4.7	223.8	132.5	718.8
	1 p. m. to 7 p. m..	493.7	+ .06	+3.6	+ 9.1	227.6	134.7	641.1
	7 p. m. to 1 a. m..	426.7	− .01	− .6	.....	236.0	139.7	565.8
	1 a. m. to 7 a. m..	297.7	+ .01	+ .6	.....	209.2	123.9	422.2
	Total.....	1,801.5	+ .03	+1.8	+13.8	896.6	530.8	2,347.9
	Total, 3 days.	5,257.7	.....	− .6	+53.1	2,578.3	1,526.4	6,836.6

Balance of income and outgo of matter and energy.—The income and outgo of nitrogen, carbon, hydrogen, and energy are shown in Tables 62–65.

In earlier experiments it was assumed that body fat contained 76.5 per cent carbon and 12 per cent hydrogen, with a heat of combustion of 9.5 calories per gram. Late determinations of the composition and heat of combustion of body fat by Benedict and Osterberg[a] essentially confirm these factors, showing 76.1 per cent carbon, 11.8 per cent hydrogen, and 9.54 calories per gram. These latter factors have been used in the computations of results of all experiments including and subsequent to No. 21. This change in factor, however, makes extremely little difference in the final results, so that it has not been thought best to recalculate those for experiments preceding No. 21 according to the new factors.

[a] Amer. Jour. Physiol., 4 (1900), p. 74.

TABLE 62.—*Income and outgo of nitrogen and carbon—Metabolism experiment No. 21.*

Time.	Nitrogen.				Carbon.				
	(*a*) In food.	(*b*) In feces.	(*c*) In urine.	(*d*) Gain (+) or loss (−), $a-(b+c)$.	(*e*) In food.	(*f*) In feces.	(*g*) In urine.	(*h*) In respiratory products.	(*k*) Gain (+) or loss (−), $e-(f+g+h)$.
1899.	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*
Feb. 12–13, 7 a. m. to 7 a. m	15.5	1.0	14.5	0	215.2	9.0	10.2	215.2	−19.2
13–14, 7 a. m. to 7 a. m	15.5	1.1	16.2	−1.8	215.2	9.0	11.3	214.6	−19.7
14–15, 7 a. m. to 7 a. m	15.5	1.0	15.4	−.9	215.2	9.0	10.9	222.5	−27.2
Total, 3 days	46.5	3.1	46.1	−2.7	645.6	27.0	32.4	652.3	−66.1
Average, 1 day	15.5	1.0	15.4	−.9	215.2	9.0	10.8	217.4	−22.0

TABLE 63.—*Income and outgo of water and hydrogen—Metabolism experiment No. 21.*

Time.	Water.					
	(*a*) In food.	(*b*) In drink.	(*c*) In feces.	(*d*) In urine.	(*e*) In respiratory products.	(*f*) Apparent loss, $a+b-(c+d+e)$.
1899.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Feb. 12–13, 7 a. m. to 7 a. m	889.9	1,385.4	46.4	1,628.3	821.3	− 220.7
13–14, 7 a. m. to 7 a. m	889.9	1,383.8	46.4	1,689.5	858.4	− 320.6
14–15, 7 a. m. to 7 a. m	889.9	1,384.9	46.4	1,909.3	897.6	− 578.5
Total, 3 days	2,669.7	4,154.1	139.2	5,227.1	2,577.3	−1,119.8
Average, 1 day	889.9	1,384.7	46.4	1,742.4	859.1	− 373.3

Time.	Hydrogen.					
	(*g*) In food.	(*h*) In feces.	(*i*) In urine.	(*l*) Apparent gain, $g-(h+i)$.	(*m*) Loss from water, $f\div 9$.	(*n*) Total gain (+) or loss (−), $l+m$.
1899.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Feb. 12–13, 7 a. m. to 7 a. m	31.8	1.2	2.9	+27.7	− 24.5	+ 3.2
13–14, 7 a. m. to 7 a. m	31.8	1.3	3.2	+27.3	− 35.6	− 8.3
14–15, 7 a. m. to 7 a. m	31.8	1.2	3.1	+27.5	− 64.3	−36.8
Total, 3 days	95.4	3.7	9.2	+82.5	−124.4	−41.9
Average, 1 day	31.8	1.2	3.1	+27.5	− 41.5	−14.0

TABLE 64.—*Gain or loss of protein* ($N\times 6.25$), *fat, and water—Metabolism experiment No. 21.*

Time.	(*a*) Nitrogen gained (+) or lost (−).	(*b*) Protein gained (+) or lost (−), $a\times 6.25$.	(*c*) Total carbon gained (+) or lost (−).	(*d*) Carbon in protein gained (+) or lost (−), $b\times 0.53$.	(*e*) Carbon it fat, etc., gained (+) or lost (−), $c-d$.	(*f*) Fat gained (+) or lost (−), $e\div 0.761$.
1899.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Feb. 12–13, 7 a. m. to 7 a. m	0	0	−19.2	0	−19.2	−25.1
13–14, 7 a. m. to 7 a. m	−1.8	−11.3	−19.7	−6.0	−13.7	−17.9
14–15, 7 a. m. to 7 a. m	− .9	− 5.6	−27.2	−3.0	−24.2	−31.6
Total, 3 days	−2.7	−16.9	−66.1	−9.0	−57.1	−74.6
Average, 1 day	− .9	− 5.6	−22.0	−3.0	−19.0	−24.9

TABLE 64.—*Gain or loss of protein* ($N \times 6.25$), *fat, and water—Metabolism experiment No. 21*—Continued.

Time.	(*g*) Total hydrogen gained (+) or lost (−).	(*h*) Hydrogen in protein gained (+) or lost (−), $b \times 0.07$.	(*i*) Hydrogen in fat gained (+) or lost (−), $f \times 0.118$.	(*k*) Hydrogen in water, etc., gained (+) or lost (−), $g-(h+i)$.	(*l*) Water gained (+) or lost (−), $k \times 9$.
1899.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Feb. 12–13, 7 a. m. to 7 a. m.	+ 3.2	0	−3.0	+ 6.2	+ 56
13–14, 7 a. m. to 7 a. m.	− 8.3	− .8	−2.2	− 5.3	− 48
14–15, 7 a. m. to 7 a. m.	−36.8	− .4	−3.8	−32.6	−293
Total, 3 days	− 41.9	−1.2	−9.0	−31.7	−285
Average, 1 day	−14.0	− .4	−3.0	−10.6	− 95

TABLE 65.—*Income and outgo of energy—Metabolism experiment No. 21.*

Time.	(*a*) Heat of combustion of food eaten.	(*b*) Heat of combustion of feces.	(*c*) Heat of combustion of urine.	(*d*) Estimated heat of combustion of protein gained (+) or lost (−).	(*e*) Estimated heat of combustion of fat gained (+) or lost (−).	(*f*) Estimated energy of material oxidized in the body, $a-(b+c+d+e)$.	(*g*) Heat determined	(*h*) Heat determined greater (+) or less (−) than estimated $g-f$.	(*i*) Heat determined greater (+) or less (−) than estimated $h \div f$.
1899.	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calo. ries.*	*P. ct.*
Feb. 12–13, 7 a. m. to 7 a. m.	2,264	100	119	0	−236	2,281	2,226	− 55	−2.4
13–14, 7 a. m. to 7 a. m.	2,264	100	132	− 65	−168	2,265	2,263	− 2	− .1
14–15, 7 a. m. to 7 a. m.	2,264	100	127	− 32	−297	2,366	2,348	− 18	− .7
Total, 3 days	6,792	300	378	− 97	−701	6,912	6,837	− 75	.....
Average, 1 day	2,264	100	126	− 32	−234	2,304	2,279	− 25	−1.1

METABOLISM EXPERIMENTS NOS. 23 AND 24.

These experiments were consecutive and form the last of the experiments of 1898–99.

Subject.—E. O., as in experiments Nos. 11, 13, and 14, described above.

Occupation during experiment.—Reading, writing, etc., with as little muscular and mental activity as practicable.

Duration.—Three days each. Experiment No. 23 began at 7 a. m., March 16, and ended at 7 a. m., March 19, at which time experiment No. 24 began and continued 3 days. An experiment not here reported immediately preceded experiment No. 23, so that the subject actually spent 9 days in the respiration calorimeter. The usual preliminary period preceded the whole series of experiments.

Diet.—The diet consisted of a basal ration of beef, butter, milk, bread, parched cereal, sugar, and horseradish, furnishing 124 grams of protein and 2,546 calories of energy per day. This basal ration

was consumed alone in experiment No. 23, but was increased by a supplemental ration of 130 grams of sugar per day in experiment No. 24. The kinds and quantities of food served at each meal, and of drink at different periods of the day are given in Table 66.

TABLE 66.—*Diet in metabolism experiments Nos. 23 and 24.*

FOOD—BASAL RATION.

Food materials.	Breakfast.	Dinner.	Supper.	Total.
	Grams.	*Grams.*	*Grams.*	*Grams.*
Beef	75	75	.....	150
Butter	15	20	20	55
Milk, skimmed	350	390	390	1,130
Bread	55	100	155	310
Parched cereal	45	.....	.....	45
Sugar[a]	40	.....	.....	40
Horseradish[b]	.....	.....	.....	30

[a] Used with coffee infusion.
[b] Used chiefly with breakfast and dinner for relish.

FOOD—SUPPLEMENTAL RATION.

Metabolism experiment No. 24 ..... Sugar, 130 grams.

DRINK.

Time.	Coffee infusion.	Water.	Time.	Coffee infusion.	Water.
	Grams.	*Grams.*		*Grams.*	*Grams.*
Breakfast	260	.....	Supper	260	.....
10.30 a. m	.....	200	11.00 p. m.	.....	200
Dinner	260	.....	Total for day	[a]780	[a]600
2.30 p. m.	.....	200			

[a] The subject did not always drink the full schedule allowance of coffee and of water. The actual amount of water consumed each day is shown in the second column of Table 78.

The general routine of the experiment is shown by the following schedule. Table 68 summarizes the main statistics of the diary kept by the subject during this series of experiments.

TABLE 67.—*Daily programme—Metabolism experiments Nos. 23 and 24.*

7.00 a. m.	Rise, pass urine, weigh self, weigh absorbers.	3.30 p. m.	Drink 200 grams water.
7.45 a. m.	Breakfast.	6.30 p. m.	Supper.
10.30 a. m.	Drink 200 grams water.	7.00 p. m.	Pass urine.
1.00 p. m.	Pass urine.	11.00 p. m.	Drink 200 grams water, take cap off food aperture, retire.
1.30 p. m.	Dinner.		

TABLE 68.—*Summary of diary—Metabolism experiments Nos. 23 and 24.*

Time.	Weight of subject without clothes.	Pulse rate per minute.	Temperature.	Hygrometer readings.	
				Dry bulb.	Wet bulb.
1899.					
Experiment No. 23.	*Kilograms.*		°F.	°C.	°C.
Mar. 16, 7.00 a. m	72.89	56	97.0	20.2	15.3
3.30 p. m	.....	76	98.9	20.0	15.4
10.45 a. m	.....	65	98.4	20.4	16.0
Mar. 17, 7.00 a. m	72.67	58	97.0	20.4	15.1
3.30 p. m	.....	70	98.0	20.0	15.2
10.50 p. m	.....	66	98.0	20.2	15.4
Mar. 18, 7.00 a. m	72.70	56	96.8	20.3	14.6
3.40 p. m	.....	66	97.6	20.2	15.0
10.50 p. m	.....	66	98.3	20.1	15.2
Experiment No. 24.					
Mar. 19, 7.00 a. m	72.68	60	96.9	20.2	14.6
3.30 p. m	.....	64	98.5	19.8	14.6
10.50 p. m	.....	69	98.8	20.2	15.0
Mar. 20, 7.00 a. m	72.70	58	97.0	20.0	14.8
4.00 p. m	.....	73	99.0	20.2	15.4
10.50 p. m	.....	71	99.0	20.4	15.6
Mar. 21, 7.00 a. m	72.97	56	96.6	20.2	15.0
3.50 p. m	.....	69	99.2	20.2	15.2
10.00 p. m	.....	70	99.4	20.6	16.0
Mar. 22, 7.00 a. m	72.90	60	97.8	20.8	16.8

Detailed data of income and outgo.—The kinds and amounts of different food materials and nutrients in the daily diet are shown in Table 69. An experiment not reported here preceded No. 23. No separation of the feces was made between that experiment and No. 23, but it was assumed that the undigested material and the metabolic products would not be essentially different in the two experiments. Charcoal was taken with supper March 18 and with breakfast March 22 in order to mark the feces from the diet during experiment No. 24, which began with breakfast March 19 and ended with supper March 21. Table 70 shows the amount and composition of the feces during the experiments.

TABLE 69.—*Weight, composition, and heat of combustion of foods—Metabolism experiments Nos. 23 and 24.*

Laboratory No.	Food materials.	Weight per day.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
	Basal ration.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
3027	Beef	150	84.9	52.3	9.2	.....	8.38	35.35	5.05	395
3029	Butter	55	5.2	.6	47.7	.....	.09	38.03	5.79	441
3031	Skimmed milk	1,130	1,025.0	40.7	1.1	54.2	6.55	46.44	6.67	462
3032	Bread	310	125.2	24.5	10.5	145.7	3.94	86.95	12.34	896
3004	Parched cereal	45	2.7	5.1	.3	36.2	.82	18.63	2.78	183
.....	Sugar	40	.....	.....	.....	40.0	.....	16.84	2.59	158
3069	Horse-radish	30	26.8	.4	.....	2.5	.06	2.70	.18	11
	Total ration 1 day, experiment No. 23.	.....	**1,269.8**	**123.6**	**68.8**	**278.6**	**19.84**	**244.94**	**35.40**	**2,546**
	Supplemental ration.									
.....	Rock candy	130	.....	.....	.....	130.0	.....	54.72	8.42	515
	Total ration 1 day, experiment No. 24.	.....	**1,269.8**	**123.6**	**68.8**	**408.6**	**19.84**	**299.66**	**43.82**	**3,061**

TABLE 70.—*Weight, composition, and heat of combustion of feces—Metabolism experiments Nos. 23 and 24.*

Laboratory No.		Weight of feces.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
	Experiment No. 23.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
3035	Total, 6 days	425.7	295.0	42.1	22.1	36.2	6.77	61.47	8.81	685
	Average, 1 day	70.9	49.2	7.0	3.7	6.0	1.13	10.25	1.47	114
	Experiment No. 24.									
3036	Total, 3 days	270.0	204.4	24.5	13.2	14.6	3.91	31.43	4.46	347
	Average, 1 day	90.0	68.1	8.2	4.4	4.9	1.30	10.48	1.49	116

[a] This period includes the 3 days of the experiment proper and 3 days of a preliminary experiment not reported here.

The urine in these experiments, as in those preceding, was collected at intervals throughout the day. Instead of dividing the 24 hours into four equal periods, however, the day was subdivided into two periods of 6 hours, one of 4 and one of 8 hours. The object of this was to avoid waking the subject at 1 o'clock at night, since he experienced some difficulty in dropping to sleep readily afterwards. Tables 71 and 72 give the data for the amount and composition of the urine during these experiments. The urine was not collected after the close of the experiments. The urine had begun to decompose before the heats of combustion of the daily samples could be determined, consequently the daily elimination of energy has been computed according to the manner followed under similar circumstances in experiments Nos. 13 and 14.

TABLE 71.—*Amount, specific gravity, and nitrogen of urine by 6-hour periods—Metabolism experiments Nos. 23 and 24.*

Date.	Period.	Amount of urine.	Specific gravity.	Nitrogen content.	
1899.	*Experiment No. 23.*	*Grams.*		*Per cent.*	*Grams.*
Mar. 16–17	7 a. m. to 1 p. m.	498.6	1.011	0.66	3.29
	1 p. m. to 7 p. m.	844.8	1.010	.68	5.74
	7 p. m. to 11 p. m.	374.6	1.020	1.32	4.95
	11 p. m. to 7 a. m.	581.1	1.010	.83	4.82
	Total				18.80
	Total by composite	2,299.1	1.013	.81	18.62
17–18	7 a. m. to 1 p. m.	402.9	1.017	1.14	4.59
	1 p. m. to 7 p. m.	834.3	1.011	[a]	
	7 p. m. to 11 p. m.	345.2	1.014	.86	2.97
	11 p. m. to 7 a. m.	697.6	1.010	.82	5.72
	Total				[b]
	Total by composite	2,280.0	1.012	.86	19.61
18–19	7 a. m. to 1 p. m.	312.7	1.018	1.31	4.10
	1 p. m. to 7 p. m.	663.3	1.010	.63	4.18
	7 p. m. to 11 p. m.	588.1	1.017	.96	5.65
	11 p. m. to 7 a. m.	432.1	1.013	1.05	4.54
	Total				18.47
	Total by composite	1,996.2	1.013	.91	18.17
	Experiment No. 24.				
Mar. 19–20	7 a. m. to 1 p. m.	409.9	1.016	1.12	4.59
	1 p. m. to 7 p. m.	770.3	1.012	.76	5.85
	7 p. m. to 11 p. m.	285.2	1.017	1.16	3.31
	11 p. m. to 7 a. m.	760.1	1.010	.75	5.70
	Total				19.45
	Total by composite	2,225.5	1.014	.89	19.81
20–21	7 a. m. to 1 p. m.	344.4	1.018	1.19	4.10
	1 p. m. to 7 p. m.	661.8	1.013	.87	5.76
	7 p. m. to 11 p. m.	294.2	1.019	1.20	3.53
	11 p. m. to 7 a. m.	570.5	1.011	.82	4.68
	Total				18.07
	Total by composite	1,870.9	1.013	.96	17.96
21–22	7 a. m. to 1 p. m.	490.0	1.012	.84	4.12
	1 p. m. to 7 p. m.	651.6	1.014	.85	5.54
	7 p. m. to 11 p. m.	257.1	1.017	1.12	2.88
	11 p. m. to 7 a. m.	462.8	1.014	1.02	4.72
	Total				17.26
	Total by composite	1,861.5	1.014	.94	17.50

[a] Sample decomposed before percentage of nitrogen was accurately determined.
[b] Nitrogen in composite taken for computations.

TABLE 72.—*Daily elimination of carbon, hydrogen, water, and energy in urine—Metabolism experiments Nos. 23 and 24.*

Date.	Amount of urine.	Carbon.		Hydrogen.		Water.		Heat of combustion.	
								Per gram.	Total.
1899.									
Experiment No. 23.	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*Calorie.*	*Calories.*
Mar. 16–17	2,299.1	.....	12.11	.....	3.55	.....	2,234.3	.....	140
17–18	2,280.0	.....	12.62	.....	3.70	.....	2,212.4	.....	146
18–19	1,996.2	.....	11.90	.....	3.49	.....	1,932.5	.....	137
Experiment No. 24.									
Mar. 19–20	2,225.5	.....	12.53	.....	3.67	.....	2,158.5	.....	145
20–21	1,870.9	.....	11.64	.....	3.41	.....	1,808.6	.....	134
21–22	1,861.5	.....	11.11	.....	3.26	.....	1,802.0	.....	128
Total, 9 days[a]	18,540.8	0.58	107.53	0.17	31.52	96.9	17,965.3	0.067	1,242

[a] This period includes the 6 days of experiments 23 and 24 and 3 days of a preliminary experiment not reported here.

The results of the determination of carbon dioxid and water in the ventilating air current are given in Tables 73–75:

TABLE 73.—*Comparison of residual amounts of carbon dioxid and water in the chamber at the beginning and end of each period, and the corresponding gain or loss—Metabolism experiments Nos. 23 and 24.*

Date.	End of period.	Carbon dioxid.		Water.		
		Total amount in chamber.	Gain (+) or loss (−) over preceding period.	Total amount of vapor remaining in chamber.	Gain (+) or loss (−) over preceding period.	Total amount gained (+) or lost (−) during the period.[a]
1899.	*Experiment No. 23.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 16–17	7 a. m.	24.5	.....	35.2	.....	.....
	1 p. m.	44.3	+19.8	40.5	+ 5.3	+ 5.3
	7 p. m.	40.9	− 3.4	43.2	+ 2.7	+ 2.7
	1 a. m.	29.8	−11.1	45.6	+ 2.4	+ 2.4
	7 a. m.	25.2	− 4.6	37.7	− 7.9	− 7.9
	Total	.....	+ .7	.....	+ 2.5	+ 2.5
17–18	1 p. m.	39.9	+14.7	40.1	+ 2.4	+ 2.4
	7 p. m.	36.3	− 3.6	41.8	+ 1.7	+ 1.7
	1 a. m.	26.7	− 9.6	37.4	− 4.4	− 4.4
	7 a. m.	25.0	− 1.7	33.5	− 3.9	− 3.9
	Total	.....	− .2	.....	− 4.2	− 4.2
18–19	1 p. m.	45.0	+20.0	39.2	+ 5.7	+ 5.7
	7 p. m.	42.1	− 2.9	39.7	+ .5	+ .5
	1 a. m.	27.3	−14.8	38.4	− 1.3	− 1.3
	7 a. m.	26.4	− .9	34.5	− 3.9	− 3.9
	Total	.....	+ 1.4	.....	+ 1.0	+ 1.0
	Experiment No. 24.					
Mar. 19–20	1 p. m.	40.3	+13.9	37.9	+ 3.4	+ 3.4
	7 p. m.	34.9	− 5.4	35.1	− 2.8	− 2.8
	1 a. m.	26.6	− 8.3	39.0	+ 3.9	+ 3.9
	7 a. m.	27.8	+ 1.2	38.9	− .1	− .1
	Total	.....	+ 1.4	.....	+ 4.4	+ 4.4
20–21	1 p. m.	45.6	+17.8	40.2	+ 1.3	+ 1.3
	7 p. m.	38.6	− 7.0	41.5	+ 1.3	+ 1.3
	1 a. m.	29.1	− 9.5	41.1	− .4	− .4
	7 a. m.	24.1	− 5.0	36.7	− 4.4	− 4.4
	Total	.....	− 3.7	.....	− 2.2	− 2.2
21–22	1 p. m.	41.2	+17.1	39.6	+ 2.9	+ 2.9
	7 p. m.	44.4	+ 3.2	44.6	+ 5.0	+ 5.0
	1 a. m.	26.5	−17.9	44.3	− .3	− .3
	7 a. m.	30.4	+ 3.9	46.8	+ 2.5	+ 2.5
	Total	.....	+ 6.3	.....	+10.1	+10.1

[a] The variations in the weights of the absorbers were so small as to be within the limits of error in weighing. They are not taken into account in the calculations. There was no drip.

TABLE 74.—*Record of carbon dioxid in ventilating air current—Metabolism experiments Nos. 23 and 24.*

Date.	Period.	(a) Ventilation (number of liters of air).	Carbon dioxid. In incoming air. (b) Per liter.	(c) Total, $a \times b$	(d) In outgoing air.	(e) Total excess in outgoing air, $d-c$.	(f) Correction for amount remaining in chamber.	(g) Corrected amount exhaled by subject, $e+f$.	(h) Total weight of carbon exhaled, $g \times \frac{3}{11}$.
1899.	*Experiment No. 23.*	*Liters.*	*Mg.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 16-17	7 a. m. to 1 p. m ...	24,857	0.700	17.4	234.9	217.5	+19.8	237.3	64.7
	1 p. m. to 7 p. m...	26,329	.706	18.6	245.9	227.3	− 3.4	223.9	61.1
	7 p. m to 1 a. m. ..	27,749	.609	16.9	233.3	216.4	−11.1	205.3	56.0
	1 a. m. to 7 a. m...	27,618	.567	15.7	151.3	135.6	− 4.6	131.0	35.7
	Total	106,553	.....	68.6	865.4	796.8	+ .7	797.5	217.5
17-18	7 a. m. to 1 p. m ...	27,110	.566	15.4	236.3	220.9	+14.7	235.6	64.2
	1 p. m. to 7 p. m ...	26,569	.556	14.8	232.8	218.0	− 3.6	214.4	58.5
	7 p. m. to 1 a. m ...	28,339	.582	16.5	225.7	209.2	− 9.6	199.6	54.4
	1 a. m. to 7 a. m ...	28,209	.588	16.6	152.1	135.5	− 1.7	133.8	36.5
	Total	110,227	.....	63.3	846.9	783.6	− .2	783.4	213.6
18-19	7 a. m. to 1 p. m ...	26,108	.566	14.8	248.3	233.5	+20.0	253.5	69.1
	1 p. m to 7 p. m ...	26,608	.548	14.6	227.4	212.8	− 2.9	209.9	57.2
	7 p. m. to 1 a. m ..	27,694	.577	16.0	235.9	219.9	−14.8	205.1	55.9
	1 a. m. to 7 a. m. ..	27,572	.578	15.9	148.7	132.8	− .9	131.9	36.0
	Total	107,982	.....	61.3	860.3	799.0	+ 1.4	800.4	218.2
	Total, 3 days.	324,762	.....	193.2	2,572.6	2,379.4	+ 1.9	2.381.3	649.3
	Experiment No. 24.								
19-20	7 a. m. to 1 p. m ...	27,538	.580	16.0	241.6	225.6	+13.9	239.5	65.3
	1 p. m. to 7 p. m ...	27,829	.557	15.5	243.3	227.8	− 5.4	222.4	60.6
	7 p. m. to 1 a. m ...	27,889	.655	18.2	248.6	230.4	− 8.3	222.1	60.6
	1 a. m. to 7 a. m ...	27,385	.639	17.5	153.7	136.2	+ 1.2	137.4	37.5
	Total	110,641	.....	67.2	887.2	820.0	+ 1.4	821.4	224.0
20-21	7 a. m. to 1 p. m ...	26,295	.564	14.8	256.4	241.6	+17.8	259.4	70.7
	1 p. m. to 7 p. m ...	26,624	.572	15.2	251.0	235.8	− 7.0	228.8	62.4
	7 p. m. to 1 a. m ...	27,671	.601	16.6	237.5	220.9	− 9.5	211.4	57.6
	1 a. m. to 7 a. m ...	27,938	.549	15.3	159.9	144.6	− 5.0	139.6	38.1
	Total	108,528	.....	61.9	904.8	842.9	− 3.7	839.2	228.8
21-22	7 a. m. to 1 p. m ...	26,162	.609	15.9	249.4	233.5	+17.1	250.6	68.3
	1 p. m. to 7 p. m...	26,049	.582	15.1	243.4	228.3	+ 3.2	231.5	63.1
	7 p. m. to 1 a. m ...	27,718	.575	15.9	277.7	261.8	−17.9	243.9	66.5
	1 a. m. to 7 a. m ...	27,370	.571	15.6	165.2	149.6	+ 3.9	153.5	41.9
	Total	107,299	.....	62.5	935.7	873.2	+ 6.3	879.5	239.8
	Total, 3 days.	326,468	.....	191.6	2,727.7	2,536.1	+ 4.0	2,540.1	692.6

TABLE 75.—*Record of water in ventilating air current—Metabolism experiments Nos. 23 and 24.*

Date.	Period.	(a) Ventilation (number of liters of air).	Water in incoming air. (b) Per liter.	Water in incoming air. (c) Total, $a \times b$.	Water in outgoing air. (d) Amount condensed in freezers.	Water in outgoing air. (e) Amount not condensed in freezers.	Water in outgoing air. (f) Total, $d+e$.	(g) Total excess water in outgoing air, $f-c$.	(h) Correction for water remaining in chamber.	(i) Total water of respiration and perspiration, $g+h$.
	Experiment No. 23.									
1899.		*Liters.*	*Mg.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 16–17	7 a. m. to 1 p. m..	24,857	0.830	20.6	180.1	35.5	215.6	195.0	+ 5.3	200.3
	1 p. m. to 7 p. m..	26,329	.787	20.7	193.5	35.5	229.0	208.3	+ 2.7	211.0
	7 p. m. to 1 a. m..	27,749	.719	20.0	232.4	42.3	274.7	254.7	+ 2.4	257.1
	1 a. m. to 7 a. m..	27,618	.730	20.2	208.4	35.6	244.0	223.8	− 7.9	215.9
	Total.....	106,553	.....	81.5	814.4	148.9	963.3	881.8	+ 2.5	884.3
17–18	7 a. m. to 1 p. m..	27,110	.730	19.8	190.1	38.8	228.9	209.1	+ 2.4	211.5
	1 p. m. to 7 p. m..	26,569	.718	19.1	193.3	33.9	227.2	208.1	+ 1.7	209.8
	7 p. m. to 1 a. m..	28,339	.712	20.2	201.1	42.6	243.7	223.5	− 4.4	219.1
	1 a. m. to 7 a. m..	28,209	.718	20.2	177.6	36.6	214.2	194.0	− 3.9	190.1
	Total.....	110,227	.....	79.3	762.1	151.9	914.0	834.7	− 4.2	830.5
18–19	7 a. m. to 1 p. m..	26,108	.758	19.8	169.6	36.7	206.3	186.5	+ 5.7	192.2
	1 p. m. to 7 p. m..	26,608	.778	20.7	184.7	33.9	218.6	197.9	+ .5	198.4
	7 p. m. to 1 a. m..	27,694	.776	21.5	197.0	42.6	239.6	218.1	− 1.3	216.8
	1 a. m. to 7 a. m..	27,572	.771	21.3	189.2	35.6	224.8	203.5	− 3.9	199.6
	Total.....	107,982	.....	83.3	740.5	148.8	889.3	806.0	+ 1.0	807.0
	Total, 3 days.	324,762	.....	244.1	2,317.0	449.6	2,766.6	2,522.5	− 0.7	2,521.8
	Experiment No. 24.									
Mar. 19–20	7 a. m. to 1 p. m..	27,538	.802	22.1	183.3	40.0	223.3	201.2	+ 3.4	204.6
	1 p. m. to 7 p. m..	27,829	.785	21.8	195.3	36.7	232.0	210.2	− 2.8	207.4
	7 p. m. to 1 a. m..	27,889	.759	21.2	220.0	41.9	261.9	240.7	+ 3.9	244.6
	1 a. m. to 7 a. m..	27,385	.744	20.4	209.6	33.7	243.3	222.9	− .1	222.8
	Total.....	110,641	.....	85.5	808.2	152.3	960.5	875.0	+ 4.4	879.4
20–21	7 a. m. to 1 p. m..	26,296	.749	19.7	191.6	35.5	227.1	207.4	+ 1.3	208.7
	1 p. m. to 7 p. m..	26,624	.706	18.8	204.9	32.0	236.9	218.1	+ 1.3	219.4
	7 p. m. to 1 a. m..	27,671	.689	19.1	214.0	40.7	254.7	235.6	− .4	235.7
	1 a. m. to 7 a. m..	27,938	.702	19.6	204.4	35.3	239.7	220.1	− 4.4	215.2
	Total.....	108,528	.....	77.2	814.9	143.5	958.4	881.2	− 2.2	879.0
21–22	7 a. m. to 1 p. m..	26,162	.702	18.4	186.8	34.3	221.1	202.7	+ 2.9	205.6
	1 p. m. to 7 p. m..	26,049	.693	18.1	200.1	31.0	231.1	213.0	+ 5.0	218.0
	7 p. m. to 1 a. m..	27,718	.717	19.9	253.0	41.0	294.0	274.1	− .3	273.8
	1 a. m. to 7 a. m..	27,370	.733	20.1	246.6	35.9	282.5	262.4	+ 2.5	264.9
	Total.....	107,299	.....	76.5	886.5	142.2	1,028.7	952.2	+10.1	962.3
	Total, 3 days.	326,468	.....	239.2	2,509.6	438.0	2,947.6	2,708.4	+12.3	2,720.7

Table 76 shows the amount of heat carried away in the water current and in the water vapor in successive 6-hour periods of experiments Nos. 23 and 24.

TABLE 76.—*Summary of calorimetric measurements—Metabolism experiments Nos. 23 and 24.*

Date.	Period.	(*a*) Heat measured in terms of C_{20}.	(*b*) Change of temperature of calorimeter.	(*c*) Capacity correction of calorimeter, $b \times 60$.	(*d*) Correction due to temperature of food and dishes.	(*e*) Water vaporized equals total amount exhaled less amount condensed in chamber.	(*f*) Heat used in vaporization of water, $e \times 0.592$.	(*g*) Total heat determined, $a+c+d+f$.
1899.	*Experiment No. 23.*	*Calories.*	*Degree.*	*Calories.*	*Calories.*	*Grams.*	*Calories.*	*Calories.*
Mar. 16–17	7 a. m. to 1 p. m.	485.4	+0.21	+12.6	− 17.5	200.3	118.6	599.1
	1 p. m. to 7 p. m.	521.4	− .07	− 4.2	− 23.9	211.0	124.9	618.2
	7 p. m. to 1 a. m.	452.2	− .05	− 3.0	.....	257.1	152.2	601.4
	1 a. m. to 7 a. m.	252.0	+ .05	+ 3.0	.....	215.9	127.8	382.8
	Total	1,711.0	+ .14	+ 8.4	− 41.4	884.3	523.5	2,201.5
17–18	7 a. m. to 1 p. m.	477.4	.....	.....	− 18.6	211.5	125.2	584.0
	1 p. m. to 7 p. m.	502.4	+ .01	+ .6	− 28.7	209.8	124.2	598.5
	7 p. m. to 1 a. m.	418.1	.....	.....	.....	219.1	129.7	547.8
	1 a. m. to 7 a. m.	302.4	.....	.....	.....	190.1	112.5	414.9
	Total	1,700.3	+ .01	+ .6	− 47.3	830.5	491.6	2,145.2
18–19	7 a. m. to 1 p. m.	513.8	.....	.....	− 16.0	192.2	113.8	611.6
	1 p. m. to 7 p. m.	510.0	− .02	− 1.2	− 28.1	198.4	117.5	598.2
	7 p. m. to 1 a. m.	448.9	+ .02	+ 1.2	.....	216.8	128.3	578.4
	1 a. m. to 7 a. m.	277.7	− .06	− 3.6	.....	199.6	118.2	392.3
	Total	1,750.4	− .06	− 3.6	− 44.1	807.0	477.8	2,180.5
	Total, 3 days.	5,161.7	− .09	+ 5.4	−132.8	2,521.8	1,492.9	6,527.2
	Experiment No. 24.							
Mar. 19–20	7 a. m. to 1 p. m.	497.6	+ .01	+ .6	− 18.5	204.6	121.1	600.8
	1 p. m. to 7 p. m.	510.9	+ .05	+ 3.0	− 29.9	207.4	122.8	606.8
	7 p. m. to 1 a. m.	450.5	.....	.....	.....	244.6	144.8	595.3
	1 a. m. to 7 a. m.	278.8	+ .03	+ 1.8	.....	222.8	131.9	412.5
	Total	1,737.8	+ .09	+ 5.4	− 48.4	879.4	520.6	2,215.4
20–21	7 a. m. to 1 p. m.	520.9	+ .01	+ .6	− 14.3	208.7	123.5	630.7
	1 p. m. to 7 p. m.	515.8	− .04	− 2.4	− 31.8	219.4	129.9	611.5
	7 p. m. to 1 a. m.	436.8	+ .02	+ 1.2	.....	235.2	139.2	577.2
	1 a. m. to 7 a. m.	279.2	− .06	− 3.6	.....	215.7	127.7	403.3
	Total	1,752.7	− .07	− 4.2	− 46.1	879.0	520.3	2,222.7
21–22	7 a. m. to 1 p. m.	590.0	+ .04	+ 2.4	− 14.7	205.6	121.7	699.4
	1 p. m. to 7 p. m.	443.1	.....	.....	− 29.9	218.0	129.1	542.3
	7 p. m. to 1 a. m.	569.5	− 01	− .6	.....	273.8	162.1	731.0
	1 a. m. to 7 a. m.	248.9	+ .01	+ .6	.....	264.9	156.8	406.3
	Total	1,851.5	+ .04	+ 2.4	− 44.6	962.3	569.7	2,379.0
	Total, 3 days.	5,342.0	+ 06	+ 3.6	−139.1	2,720.7	1,610.6	6,817.1

Balance of income and outgo of matter and energy.—The income and outgo of nitrogen, carbon, hydrogen, and energy in experiments Nos. 23 and 24 are shown in Tables 77–80.

TABLE 77.—*Income and outgo of nitrogen and carbon—Metabolism experiments Nos. 23 and 24.*

Time.	Nitrogen.				Carbon.				
	(*a*) In food.	(*b*) In feces.	(*c*) In urine.	(*d*) Gain (+) or loss (−), *a*−(*b*+*c*).	(*e*) In food.	(*f*) In feces.	(*g*) In urine.	(*h*) In respiratory products.	(*k*) Gain (+) or loss(−), *e*−(*f*+*g*+*h*).
1899.									
Experiment No. 23.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 16–17, 7 a. m. to 7 a. m..	19.8	1.1	18.8	−0.1	244.9	10.2	12.1	217.5	+ 5.1
17–18, 7 a. m. to 7 a. m..	19.9	1.2	19.6	− .9	245.0	10.3	12.6	213.6	+ 8.5
18–19, 7 a. m. to 7 a. m..	19.8	1.1	18.5	+ .2	244.9	10.2	11.9	218.2	+ 4.6
Total, 3 days.....	59.5	3.4	56.9	− .8	734.8	30.7	36.6	649.3	+ 18.2
Average, 1 day.....	19.8	1.1	19.0	− .3	244.9	10.2	12.2	216.4	+ 6.1
Experiment No. 24.									
Mar. 19–20, 7 a. m. to 7 a. m..	19.8	1.3	19.4	− .9	299.7	10.5	12.5	224.0	+ 52.7
20–21, 7 a. m. to 7 a. m..	19.9	1.3	18.1	+ .5	299.6	10.5	11.7	228.8	+ 48.6
21–22, 7 a. m. to 7 a. m..	19.8	1.3	17.3	+1.2	299.7	10.5	11.1	239.8	+ 38.3
Total, 3 days.....	59.5	3.9	54.8	+ .8	899.0	31.5	35.3	692.6	+139.6
Average, 1 day.....	19.8	1.3	18.2	+ .3	299.7	10.5	11.8	230.9	+ 46.5

TABLE 78.—*Income and outgo of water and hydrogen—Metabolism experiments Nos. 23 and 24.*

Time.	Water.					
	(*a*) In food.	(*b*) In drink.	(*c*) In feces.	(*d*) In urine.	(*e*) In respiratory products.	(*f*) Apparent loss, *a*+*b*−(*c*+*d*+*e*).
1899.						
Experiment No. 23.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 16–17, 7 a. m. to 7 a. m.....	1,269.8	1,362.8	49.2	2,234.3	884.3	− 535.2
17–18, 7 a. m. to 7 a. m.....	1,269.8	1,379.2	49.2	2,212.4	830.5	− 443.1
18–19, 7 a. m. to 7 a. m.....	1,269.8	1,378.0	49.2	1,932.5	807.0	− 140.9
Total, 3 days.....	3,809.4	4,120.0	147.6	6,379.2	2,521.8	−1,119.2
Average, 1 day	1,269.8	1,373.3	49.2	2,126.4	840.6	− 373.1
Experiment No. 24.						
Mar. 19–20, 7 a. m. to 7 a. m.....	1,269.8	1,376.0	68.1	2,158.5	879.4	− 460.2
20–21, 7 a. m. to 7 a. m.....	1,269.8	1,382.4	68.1	1,808.6	879.0	− 103.5
21–22, 7 a. m. to 7 a. m.....	1,269.8	1,373.4	68.1	1,802.0	962.3	− 189.2
Total, 3 days.....	3,809.4	4,131.8	204.3	5,769.1	2,720.7	− 752.9
Average, 1 day	1,269.8	1,377.3	68.1	1,923.0	906.9	− 250.9

TABLE 78.—*Income and outgo of water and hydrogen—Metabolism experiments Nos. 23 and 24*—Continued.

Time.	Hydrogen.					
	(*g*) In food.	(*h*) In feces.	(*i*) In urine.	(*l*) Apparent gain, *g*−(*h*+*i*).	(*m*) Loss from water, *f*+9.	(*n*) Total gain (+) or loss (−), *l*+*m*.
1899.						
Experiment No. 23.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 16–17, 7 a. m. to 7 a. m.	35.4	1.5	3.5	+ 30.4	− 59.5	−29.1
17–18, 7 a. m. to 7 a. m.	35.4	1.4	3.7	+ 30.3	− 49.2	−18.9
18–19, 7 a. m. to 7 a. m.	35.4	1.5	3.5	+ 30.4	− 15.7	+14.7
Total, 3 days	106.2	4.4	10.7	+ 91.1	−124.4	−33.3
Average, 1 day	35.4	1.5	3.6	+ 30.4	− 41.5	−11.1
Experiment No. 24.						
Mar. 19–20, 7 a. m. to 7 a. m.	43.8	1.5	3.7	+ 38.6	− 51.1	−12.5
20–21, 7 a. m. to 7 a. m.	43.8	1.5	3.4	+ 38.9	− 11.5	+27.4
21–22, 7 a. m. to 7 a. m.	43.8	1.5	3.3	+ 39.0	− 21.0	+18.0
Total, 3 days	131.4	4.5	10.4	+116.5	− 83.6	+32.9
Average, 1 day	43.8	1.5	3.5	+ 38.8	− 27.9	+10.9

TABLE 79.—*Gain or loss of protein* ($N \times 6.25$), *fat, and water—Metabolism experiments Nos. 23 and 24.*

Time.	(*a*) Nitrogen gained (+) or lost (−).	(*b*) Protein gained (+) or lost (−), *a*×6.25.	(*c*) Total carbon gained (+) or lost (−).	(*d*) Carbon in protein gained (+) or lost (−), *b*×0.53.	(*e*) Carbon in fat, etc., gained (+) or lost (−), *c*−*d*.	(*f*) Fat gained (+) or lost (−), *e*÷0.761.
1889.						
Experiment No. 23.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 16–17, 7 a. m. to 7 a. m.	−0.1	−0.6	+ 5.1	0.0	+ 5.1	+ 6.7
17–18, 7 a. m. to 7 a. m.	− .9	−5.6	+ 8.5	−3.0	+ 11.5	+ 15.0
18–19, 7 a. m. to 7 a. m.	+ .2	+1.3	+ 4.6	+ .7	+ 3.9	+ 5.1
Total, 3 days	− .8	−4.9	+ 18.2	−2.3	+ 20.5	+ 26.8
Average, 1 day	− .3	−1.6	+ 6.1	− .8	+ 6.9	+ 9.0
Experiment No. 24.						
Mar. 19–20, 7 a. m. to 7 a. m.	− .9	−5.6	+ 52.7	−3.0	+ 55.7	+ 72.8
20–21, 7 a. m. to 7 a. m.	+ .5	+3.1	+ 48.6	+1.6	+ 47.0	+ 61.5
21–22, 7 a. m. to 7 a. m.	+1.2	+7.5	+ 38.3	+4.0	+ 34.3	+ 44.8
Total, 3 days	+ .8	+5.0	+139.6	+2.6	+137.0	+179.1
Average, 1 day	+ .3	+1.7	+ 46.5	+ .9	+ 45.7	+ 59.7

TABLE 79.—*Gain or loss of protein (N×6.25), fat, and water—Metabolism experiments Nos. 23 and 24*—Continued.

Time.	(*g*) Total hydrogen gained (+) or lost (−).	(*h*) Hydrogen in protein gained (+) or lost (−), $b \times 0.07$.	(*i*) Hydrogen in fat gained (+) or lost (−), $f \times 0.118$.	(*k*) Hydrogen in water, etc., gained (+) or lost (−), $g-(h+i)$.	(*l*) Water gained (+) or lost (−), $k \times 9$.
1899.					
Experiment No. 23.	*Grams.*	*Gram.*	*Grams.*	*Grams.*	*Grams.*
Mar. 16–17, 7 a. m. to 7 a. m	−29.1	0.0	+ 0.8	−29.9	−269.1
17–18, 7 a. m. to 7 a. m	−18.9	− .4	+ 1.8	−20.3	−182.7
18–19, 7 a. m. to 7 a. m	+14.7	+ .1	+ .6	+14.0	+126.0
Total, 3 days	−33.3	− .3	+ 3.2	−36.2	−325.8
Average, 1 day	−11.1	− .1	+ 1.1	−12.1	−108.6
Experiment No. 24.					
Mar. 19–20, 7 a. m. to 7 a. m	−12.5	− .4	+ 8.7	−20.8	−187.2
20–21, 7 a. m. to 7 a. m	+27.4	+ .2	+ 7.4	+19.8	+178.2
21–22, 7 a. m. to 7 a. m	+18.0	+ .5	+ 5.4	+12.1	+108.9
Total, 3 days	+32.9	+ .3	+21.5	+11.1	+ 99.9
Average, 1 day	+10.9	+ .1	+ 7.1	+ 3.7	+ 33.3

TABLE 80.—*Income and outgo of energy—Metabolism experiments Nos. 23 and 24.*

Time.	(*a*) Heat of combustion of food eaten.	(*b*) Heat of combustion of feces.	(*c*) Heat of combustion of urine.	(*d*) Estimated heat of combustion of protein gained (+) or lost (−).	(*e*) Estimated heat of combustion of fat gained (+) or lost (−).	(*f*) Estimated energy of material oxidized in the body, $a-(b+c+d+e)$.	(*g*) Heat determined.	(*h*) Heat determined greater (+) or less (−) than estimated, $g-f$.	(*i*) Heat determined greater (+) or less (−) than estimated, $h \div f$.
1899.									
Experiment No. 23.	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Per cent.*
Mar. 16–17, 7 a. m. to 7 a. m	2,546	114	140	− 4	+ 63	2,233	2,202	− 31	−1.4
17–18, 7 a. m. to 7 a. m	2,546	114	146	−32	+ 141	2,177	2,145	− 32	−1.5
18–19, 7 a. m. to 7 a. m	2,546	114	137	+ 8	+ 48	2,239	2,181	− 58	−2.6
Total, 3 days	7,638	342	423	−28	+ 252	6,649	6,528	−121	.....
Average, 1 day	2,546	114	141	− 9	+ 84	2,216	2,176	− 40	−1.8
Experiment No. 24.									
Mar. 19–20, 7 a. m. to 7 a. m	3,061	116	145	−32	+ 684	2,148	2,215	+ 67	+3.1
20–21, 7 a. m. to 7 a. m	3,061	116	134	+18	+ 579	2,214	2,223	+ 9	+ .4
21–22, 7 a. m. to 7 a. m	3,061	116	128	+43	+ 421	2,353	2,379	+ 26	+1.1
Total, 3 days	9,183	348	407	+29	+1,684	6,715	6,817	+102	.....
Average, 1 day	3,061	116	136	+10	+ 561	2,238	2,272	+ 34	+1.5

METABOLISM EXPERIMENT NO. 25.

Subject.—J. F. S., a chemist, 29 years of age, weighing with underclothing about 64 kilograms (141 pounds).

Occupation during experiment.—Reading, writing, and miscellaneous observations with the apparatus, with as little muscular activity as was practicable.

Duration.—Three days, beginning at 7 a. m. January 23, 1900. The usual preliminary period of 4 days duration preceded the metabolism experiment. The subject entered the calorimeter on the evening of January 22, thus spending four nights and three days in the respiration chamber.

Diet.—Inasmuch as experiment No. 25 was the first with this subject, the experiment was somewhat of a preliminary nature. The average food consumption of the subject had been determined by preliminary tests, and the diet was so arranged as to furnish approximately the nitrogen and the energy it was believed the subject required. It was intended to make this the first of a series of three experiments, in which about one-fifth of the energy of the diet should be furnished by isodynamic amounts of different materials. Unfortunately an accident to some of the machinery necessitated the stopping of the experiment shortly after the close of the first of the series of experiments. The diet consisted of a so-called basal ration furnishing about 110 grams of protein and 2,391 calories of energy, to which was added 63 grams of butter daily, furnishing 1 gram of protein and 505 calories of energy.

The kinds and quantities of food served for each meal and the quantity of drink consumed at different periods of the day are as follows:

TABLE 81.—*Diet in metabolism experiment No. 25.*

FOOD.

Food materials.	Breakfast.	Dinner.	Supper.	Total.
	Grams.	*Grams.*	*Grams.*	*Grams.*
Beef	30	55	.....	85
Butter	35	35	28	98
Milk	300	300	400	1,000
Bread	90	120	90	300
Parched cereal	25	.....	25	50
Ginger snaps	.....	35	35	70
Sugar	10	.....	10	20

DRINK.

Time.	Water.	Time.	Water.
	Grams.		*Grams.*
Breakfast	100	10.30 p. m	100
10.00 a. m	200	Total for day	900
3.00 p. m	200		
9.00 p. m	300		

Daily routine.—The daily routine was essentially the same as that in previous experiments with other subjects, with the exception that the subject observed his pulse and body temperature at more frequent intervals. The general routine was as follows:

TABLE 82.—*Daily programme—Metabolism experiment No. 25.*

6.50 a. m.....	Take pulse and temperature.	3.00 p. m.....	Drink 200 grams water.
7.00 a. m.....	Pass urine, weigh self, weigh absorbers.	6.00 p. m.....	Supper.
		6.50 p. m.....	Take pulse and temperature.
7.45 a. m.....	Breakfast, drink 100 grams water.	7.00 p. m.....	Pass urine, weigh self, weigh absorbers.
10.00 a. m.....	Drink 200 grams water.	9.00 p. m.....	Drink 300 grams water.
12.50 p. m.....	Take pulse and temperature.	10.20 p. m.....	Take pulse and temperature.
1.00 p. m.....	Pass urine.	10.30 p. m.....	Drink 100 grams water, retire.
1.15 p. m.....	Dinner.	1.00 a. m.....	Pass urine.

Table 83 summarizes the most important statistics in the diary kept by the subject. He weighed himself in underclothing twice each day. The reasons for not removing all the clothing in weighing, as was done in previous experiments, were two. It was desired to avoid the muscular work involved in dressing and undressing. It has also been found that the sudden increase of radiation of heat from the skin when the clothing was removed caused a decided rise of the temperature inside the chamber and thus disturbed the accuracy of the heat measurements to some extent. There was extremely little muscular exercise and no sensible perspiration. Hence the differences in weight from time to time may be considered to represent very nearly the actual changes in body weight.

The determinations of pulse rate were made, of course, by the subject himself, when either sitting or reclining, after several minutes' rest. The measurement at 6.50 to 7 a. m., however, was made just before rising.

The body temperature was determined by means of a mercury thermometer. The temperature was, as a rule, taken in the axilla, although numerous sublingual observations were made. The thermometer was, as a rule, left in place ten minutes before reading. While the records of body temperature thus taken are probably not as accurate as might be desired, later observations with an electrical rectal thermometer since devised for continuous and accurate observations of internal body temperature[a] lead us to believe that the daily curves for the two are nearly parallel.

In previous experiments a hygrometer had been placed in the chamber, and readings with dry and wet bulb were taken at frequent intervals. Inasmuch, however, as these readings were not used in the computations of results, and as it is desirable in rest experiments to

[a] Arch. Physiol. [Pflüger], 88 (1901), No. 9–10, p. 492.

avoid all unnecessary exercise, even that of rising and reading the hygrometer, these observations were not made in the experiments of 1900.

TABLE 83.—*Summary of the diary—Metabolism experiment No. 25.*

Time.	Weight of subject in underclothes.	Pulse rate per minute.	Temperature.		Time.	Weight of subject in underclothes.	Pulse rate per minute.	Temperature.	
			Axillary.	Sublingual.				Axillary.	Sublingual.
1900.					1900.				
January 23.	*Kgs.*		°*F.*	°*F.*	*Jan. 24*—Cont'd.	*Kgs.*		°*F.*	°*F.*
7 a. m	63.79	73	97.2		12.30 p. m		63		97.7
9 a. m		89	98.3		1.52 p. m		78		
9.05 a. m			98.5		1.55 p. m				98.5
10.15 a. m		77	97.8		2.25 p. m			98.3	
11.30 a. m		73	97.5		2.45 p. m			98.4	
11.50 a. m			97.9		3.23 p. m		84	98.6	
12 m		72	97.6		3.45 p. m			98.6	
12.10 p. m				98.3	3.46 p. m		82		98.6
12.25 p. m			97.7		4.10 p. m			98.8	
12.50 p. m			98.3		4.30 p. m		75	98.5	
1 p. m		69		97.9	4.55 p. m			98.3	
2.35 p. m			98.0		5.15 p. m		75	98.3	
2.40 p. m		78		98.3	5.30 p. m			98.2	
3.45 p. m		86	98.8		5.45 p. m		69		
3.50 p. m		82		98.7	5.48 p. m			98.3	
4.25 p. m			98.7		5.57 p. m		71		
5 p. m			98.1		6.49 p. m			98.5	
5.05 p. m		73	97.9		6.53 p. m		77		
5.35 p. m			98.3		6.57 p. m	65.13			
6.45 p. m		75		97.8	7.30 p. m		78	98.2	
7 p. m	64.63				7.38 p. m				98.2
8 p. m			98.4		8 p. m			98.2	
8.30 p. m		75	98.3		8.25 p. m			98.1	
8.40 p. m				98.2	8.30 p. m		70		97.7
9.35 p. m		68	97.7		9.21 p. m		72		
10 p. m			97.7		9.47 p. m			97.5	
10.10 p. m			97.6		10.10 p. m			97.5	
10.15 p. m			97.7		10.20 p. m		64		97.0
10.25 p. m		69		97.4	10.20 p. m				97.0
January 24.					10.25 p. m		64		97.2
6.55 a. m	64.21	67		98.1	*January 25.*				
8.30 a. m		83		98.3	6.55 a. m		71		
8.40 a. m				98.6	7.03 a. m	64.49			
9 a. m			98.6		7.38 a. m		78		
9.25 a. m		78	98.6		7.50 a. m			98.4	
9.30 a. m				98.2	8.37 a. m		86		
9.35 a. m				98.4	8.50 a. m			98.5	
9.55 a. m			98.2		8.53 a. m		82		
10.30 a. m		68	97.9		8.55 a. m				98.5
10.40 a. m		80		97.6	9.37 a. m		80		
11 a. m		74	97.2		9.47 a. m				98.3
11.25 a. m		84	98.3		10.29 a. m		76		
11.35 a. m		81			10.40 a. m			98.0	
11.55 a. m		69		97.7	10.45 a. m		71		
12.17 p. m			98.2		10.54 a. m		74		

TABLE 83.—*Summary of the diary—Metabolism experiment No. 25*—Continued.

Time.	Weight of subject in underclothes.	Pulse rate per minute.	Temperature.	
			Axillary.	Sublingual.
1900.				
Jan. 25—Cont'd.	*Kgs.*		°*F.*	°*F.*
11.10 a. m			98.0	
11.13 a. m		72		
11.25 a. m		74		
11.35 a. m			98.1	
11.39 a. m		72		
11.53 a. m		69		
12.09 p. m			98.0	
12.15 p. m		72		
12.27 p. m		68		
12.45 p. m		68		
12.47 p. m				98.1
2.11 p. m		81	98.7	
2.37 p. m			98.7	
2.55 p. m			98.1	
3 p. m		81		98.8
3.19 p. m			98.8	
3.26 p. m		82		
3.28 p. m				98.0
3.31 p. m				98.3
3.33 p. m				98.4
3.35 p. m				98.5
4 p. m			98.4	
4.10 p. m			98.5	
4.35 p. m		75	98.3	
4.48 p. m			98.3	
5.06 p. m			98.3	
5.23 p. m		73	98.2	
6.04 p. m			98.3	
6.43 p. m		76		
6.46 p. m			98.4	
6.59 p. m	65.19			
7.48 p. m			98.4	
7.51 p. m		69		
7.55 p. m				97.9
8.22 p. m			97.7	
8.46 p. m			97.8	
8.49 p. m		70		
8.51 p. m				97.7
9.16 p. m			97.8	
9.31 p. m			97.8	
9.46 p. m			97.8	
9.49 p. m		70		
10.10 p. m			97.4	
10.17 p. m		70		
10.20 p. m			97.2	

Time.	Weight of subject in underclothes.	Pulse rate per minute.	Temperature.	
			Axillary.	Sublingual.
1900.				
January 26.	*Kgs.*		°*F.*	°*F.*
6.55 a. m		70		
7 a. m				98.1
7.04 a. m	64.43			
8.33 a. m		90		
8.39 a. m		88		
8.41 a. m		90		
8.42 a. m			97.9	
9.26 a. m			98.5	
9.30 a. m		91		
9.72 a. m				98.5
10 a. m			98.3	
10.27 a. m		87		
10.32 a. m			98.2	
10.44 a. m				98.2
11.01 a. m			98.2	
11.12 a. m			98.1	
11.30 a. m			97.9	
11.33 a. m		82		97.9
11.55 a. m			97.7	
12.05 p. m			97.9	
12.28 p. m			97.9	
12.34 p. m		72		
12.51 p. m		76		
12.56 p. m			97.9	
1.56 p. m		82		
2.04 p. m			98.2	
2.16 p. m			98.4	
2.27 p. m		88		
2.28 p. m			98.5	
2.45 p. m			98.5	
3.07 p. m		92		
3.08 p. m			98.6	
3.12 p. m		93		
3.21 p. m			98.5	
3.33 p. m		98	98.7	
3.45 p. m			98.7	
4 p. m			98.6	
4.39 p. m		100		
5 p. m			98.7	
5.23 p. m			98.6	
5.28 p. m		95		
5.50 p. m			98.3	
6.37 p. m		94		
6.49 p. m			98.3	
7 p. m	65.18			

Detailed data of income and outgo.—The quantities of nutrients and energy in the daily diet in this experiment are shown in Table 84, and the total and daily elimination of matter and energy in the feces in Table 85.

TABLE 84.—*Weight, composition, and heat of combustion of foods—Metabolism experiment No. 25.*

Laboratory No.	Food materials.	Weight per day.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
3165	Beef	85	53.4	28.5	2.8	.....	4.56	16.68	2.35	185
3166	Butter	98	8.6	1.6	84.4	.....	.25	62.10	9.81	786
3169	Milk, skimmed	1,000	894.0	43.0	4.0	51.0	6.80	47.60	6.70	488
3164	Bread	300	115.8	27.3	6.3	146.7	4.38	84.12	12.09	841
3168	Parched cereal	50	2.8	5.9	.9	39.6	.94	21.10	2.97	207
3167	Ginger snaps	70	3.4	4.5	6.0	54.9	.72	30.91	4.49	310
	Sugar	20	.....	.....	.....	20.0	.....	8.42	1.30	79
	Total	1,623	1,078.0	110.8	104.4	312.2	17.65	270.93	39.71	2,896

TABLE 85.—*Weight, composition, and heat of combustion of feces—Metabolism experiment No. 25.*

Laboratory No.		Weight of feces.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
3171	Total, 3 days	211.4	145.8	18.2	8.0	23.4	2.92	29.02	4.27	332
	Average, 1 day	70.5	48.6	6.1	2.7	7.8	.97	9.67	1.42	111

The urine was collected and the nitrogen determined in the usual 6-hour periods each day. The usual aliquot portions of the urine during each period of the day were taken for the preparation of a composite sample for the day. The nitrogen and heat of combustion of this composite sample were determined. Aliquot portions of the urine for each day were taken for the preparation of a composite sample for the whole period of the experiment. Inasmuch as it was intended that this experiment should form a part of a series continuing for 9 days, a composite sample of the urine for the 3 days of experiment No. 25 was not made, but a corresponding sample for 5 days was prepared and analyzed in the usual manner. The statistics are shown in Tables 86 and 87. The quantities of carbon dioxid and water found in the ventilating air current during the different days of this experiment are shown in Tables 88–90. Table 90 summarizes the calorimetric measurements during the experiment.

TABLE 86.—*Amount, specific gravity, and nitrogen of urine by 6-hour periods—Metabolism experiment No. 25.*

Date.	Period.	Amount of urine.	Specific gravity.	Nitrogen content.	
1900.		*Grams.*		*Per cent.*	*Grams.*
Jan. 23–24	7 a. m. to 1 p. m	281.1	1.027	1.40	3.94
	1 p. m. to 7 p. m	314.6	1.029	1.60	5.03
	7 p. m. to 1 a. m	201.5	1.032	2.03	4.09
	1 a. m. to 7 a. m	178.0	1.028	1.90	3.38
	Total	975.2	.....	.....	16.44
	Total by composite	975.2	1.0285	1.69	16.48
24–25	7 a. m. to 1 p. m	256.6	1.026	1.51	3.87
	1 p. m. to 7 p. m	380.3	1.032	1.27	4.83
	7 p. m. to 1 a. m	225.8	1.027	1.79	4.04
	1 a. m. to 7 a. m	349.3	1.016	1.06	3.70
	Total	1,212.0	.....	.....	16.44
	Total by composite	1,212.0	1.022	1.35	16.48
25–26	7 a. m. to 1 p. m	355.2	1.022	1.09	3.87
	1 p. m. to 7 p. m	430.7	1.019	1.08	4.65
	7 p. m. to 1 a. m	303.8	1.021	1.34	4.07
	1 a. m. to 7 a. m	461.1	1.014	.82	3.78
	Total	1,550.8	.....	.....	16.37
	Total by composite	1,550.8	1.019	1.07	16.59
26–27	7 a. m. to 1 p. m	402.6	1.019	.92	3.70
	1 p. m. to 7 p. m	441.3	1.018	1.00	4.41
	7 p. m. to 1 a. m	375.6	1.017	1.08	4.06
	1 a. m. to 7 a. m	305.6	1.019	1.12	3.42
	Total	1,525.1	.....	.....	15.59
	Total by composite	1,525.1	1.0185	1.03	15.71
27–28	7 a. m. to 1 p. m	331.8	1.021	1.16	3.85
	1 p. m. to 7 p. m	448.3	1.019	1.07	4.80
	7 p. m. to 1 a. m	405.0	1.017	1.15	4.66
	1 a. m. to 7 a. m	280.3	1.020	1.24	3.47
	Total	1,465.4	.....	.....	16.78
	Total by composite	1,465.4	1.019	1.15	16.85
	Total, 5 days, by composite	6,728.5	.....	1.21	81.41

TABLE 87.—*Daily elimination of carbon, hydrogen, water, and energy in urine—Metabolism experiment No. 25.*

Date.	Amount of urine.	Carbon.		Hydrogen.		Water.		Heat of combustion.	
								Per gram.	Total.
1900.	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*Cal.*	*Calories.*
Jan. 23–24	975.2	.....	12.88	.....	3.12	.....	913.1	0.142	138.5
24–25	1,212.0	.....	12.87	.....	3.12	.....	1,150.0	.121	146.6
25–26	1,550.8	.....	12.82	.....	3.10	.....	1,489.0	.100	155.1
26–27	1,525.1	.....	12.21	.....	2.96	.....	1,466.2	.096	146.4
27–28	1,465.4	.....	13.14	.....	3.18	.....	1,402.0	.....	.....
Total, 5 days	6,728.5	0.95	63.92	0.23	15.48	95.42	6,420.3	.....	.....

TABLE 88.—*Comparison of residual amounts of carbon dioxid and water in the chamber at the beginning and end of each period, and the corresponding gain or loss—Metabolism experiment No. 25.*

Date.	End of period	Carbon dioxid.		Water.			
		Total amount in chamber.	Gain (+) or loss (−) over preceding period.	Total amount of vapor remaining in chamber.	Gain (+) or loss (−) over preceding period.	Change in weight of absorbers, gain (+) or loss (−).	Total amount gained (+) or lost (−) during the period.
1900.		*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Jan. 23	7 a. m.	27.4	.....	36.5	.....	.....	.....
23	1 p. m.	36.7	+ 9.3	42.9	+6.4	+11	+17.4
23	7 p. m.	45.6	+ 8.9	44.1	+1.2	+10	+11.2
24	1 a. m.	27.6	−18.0	43.9	− .2	−11	−11.2
24	7 a. m.	26.6	− 1.0	37.4	−6.5	−10	−16.5
	Total	.....	− .8	.....	+ .9	0	+ .9
24	1 p. m.	38.6	+12.0	41.8	+4.4	+ 1	+ 5.4
24	7 p. m.	44.6	+ 6.0	39.3	−2.5	+ 1	− .5
25	1 a. m.	26.0	−18.6	41.2	+1.9	− 2	− .1
25	7 a. m.	24.9	− 1.1	35.0	−6.2	− 2	− 8.2
	Total	.....	− 1.7	.....	−2.4	− 2	− 4.4
25	1 p. m.	35.5	+10.6	40.3	+5.3	− 1	+ 4.3
25	7 p. m.	46.7	+11.2	43.5	+3.2	0	+ 3.2
26	1 a. m.	26.8	−19.9	40.3	−3.2	0	− 3.2
26	7 a. m.	26.4	− .4	36.5	−3.8	0	− 3.8
	Total	.....	+ 1.5	.....	+1.5	− 1	+ .5
	Total, 3 days	.....	− 1.0	.....	0	− 3	− 3.0

TABLE 89.—*Record of carbon dioxid in ventilating air current—Metabolism experiment No. 25.*

Date.	Period.	(*a*)	Carbon dioxid.						(*h*)
		Ventilation (number of liters of air).	In incoming air.		(*d*) In outgoing air.	(*e*) Total excess in outgoing air, *d* − *c*.	(*f*) Correction for amount remaining in chamber.	(*g*) Corrected amount exhaled by subject, *e* + *f*.	Total weight of carbon exhaled, $g \times \frac{3}{11}$.
			(*b*) Per liter.	(*c*) Total, *a* × *b*.					
1900.		*Liters.*	*Mg.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Jan. 23-24	7 a. m. to 1 p. m.	25,652	0.624	16.0	244.9	228.9	+ 9.3	238.2	65.0
	1 p. m. to 7 p. m.	26,430	.593	15.7	247.3	231.6	+ 8.9	240.5	65.6
	7 p. m. to 1 a. m.	27,208	.561	15.3	226.6	211.3	−18.0	193.3	52.7
	1 a. m. to 7 a. m.	26,430	.539	14.2	144.0	129.8	— 1.0	128.8	35.1
	Total	105,720	.....	61.2	862.8	801.6	− .8	800.8	218.4
24-25	7 a. m. to 1 p. m.	26,430	.611	16.1	238.8	222.7	+12.0	234.7	64.0
	1 p. m. to 7 p. m.	27,208	.598	16.3	233.4	217.1	+ 6.0	223.1	60.8
	7 p. m. to 1 a. m.	27,985	.560	15.7	235.0	219.3	−18.6	200.7	54.7
	1 a. m. to 7 a. m.	27,985	.549	15.4	150.7	135.3	− 1.1	134.2	36.6
	Total	109,608	.....	63.5	857.9	794.4	− 1.7	792.7	216.1
25-26	7 a. m. to 1 p. m.	27,207	.572	15.6	224.8	209.2	+10.6	219.8	59.9
	1 p. m. to 7 p. m.	26,430	.588	15.5	233.4	217.9	+11.2	229.1	62.5
	7 p. m. to 1 a. m.	27,985	.584	16.3	235.6	219.3	−19.9	199.4	54.5
	1 a. m. to 7 a. m.	27,208	.548	14.9	156.6	141.7	− .4	141.3	38.4
	Total	108,830	.....	62.3	850.4	788.1	+ 1.5	789.6	215.3
	Total, 3 days	324,158	.....	187.0	2,571.1	2,384.1	− 1.0	2,383.1	649.8

TABLE 90.—*Record of water in ventilating air current—Metabolism experiment No. 25.*

Date.	Period.	(a) Ventilation (number of liters of air).	Water in incoming air. (b) Per liter.	Water in incoming air. (c) Total, a×b.	Water in outgoing air. (d) Amount condensed in freezers.	Water in outgoing air. (e) Amount not condensed in freezers.	Water in outgoing air. (f) Total, d+e.	(g) Total excess water in outgoing air, f−c.	(h) Correction for water remaining in chamber.	(i) Total water of respiration and perspiration, g+h.
1900.		*Liters.*	*Mg.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Jan. 23–24	7 a. m. to 1 p. m.	25,652	0.877	22.5	191.9	46.6	238.5	216.0	+17.4	233.4
	1 p. m. to 7 p. m.	26,430	.870	23.0	210.1	37.8	247.9	224.9	+11.2	236.1
	7 p. m. to 1 a. m.	27,208	.862	23.5	212.9	42.3	255.2	231.7	−11.2	220.5
	1 a. m. to 7 a. m.	26,430	.819	21.6	190.9	36.2	227.1	205.5	−16.5	189.0
	Total	105,720	.....	90.6	805.8	162.9	968.7	878.1	+ .9	879.0
24–25	7 a. m. to 1 p. m.	26,430	.887	23.4	193.7	40.2	233.9	210.5	+ 5.4	215.9
	1 p. m. to 7 p. m.	27,208	.864	23.5	209.1	39.3	248.4	224.9	− 1.5	223.4
	7 p. m. to 1 a. m.	27,985	.834	23.3	218.5	43.7	262.2	238.9	− .1	238.8
	1 a. m. to 7 a. m.	27,985	.859	24.0	189.7	39.5	229.2	205.2	− 8.2	197.0
	Total	109,608	.....	94.2	811.0	162.7	973.7	879.5	− 4.4	875.1
25–26	7 a. m. to 1. p. m.	27,207	.853	23.2	188.7	43.9	232.6	209.4	+ 4.3	213.7
	1 p. m. to 7 p. m.	26,430	.873	23.1	197.7	37.0	234.7	211.6	+ 3.2	214.8
	7 p. m. to 1 a. m.	27,985	.841	23.6	199.7	43.3	243.0	219.4	− 3.2	216.2
	1 a. m. to 7 a. m.	27,208	.812	22.1	181.8	36.3	218.1	196.0	− 3.8	192.2
	Total	108,830	.....	92.0	767.9	160.5	928.4	836.4	+ .5	836.9
	Total, 3 days.	324,158	.....	276.8	2,384.7	486.1	2,870.8	2,594.0	− 3.0	2,591.0

TABLE 91.—*Summary of calorimetric measurements—Metabolism experiment No. 25.*

Date.	Period.	(a) Heat measured in terms of C_{20}.	(b) Change of temperature of calorimeter.	(c) Capacity correction of calorimeter, b×60.	(d) Correction due to temperature of food and dishes.	(e) Water vaporized equals total amount exhaled less amount condensed in chamber.	(f) Heat used in vaporization of water, e×0.592.	(g) Total heat determined, a+c+d+f.
1900.		*Calories.*	*Degree.*	*Calories.*	*Calories.*	*Grams.*	*Calories.*	*Calories.*
Jan. 23–24	7 a. m. to 1 p. m...	588.0	.....	.....	− 0.5	222.4	131.7	719.2
	1 p. m. to 7 p. m...	490.6	−0.01	−0.6	− 2.2	226.1	133.8	621.6
	7 p. m. to 1 a. m...	447.1	.....	.....	+ 5.9	231.5	137.1	590.1
	1 a. m. to 7 a. m...	248.5	.....	.....	.....	199.0	117.8	366.3
	Total.....	1,774.2	− .01	−0.6	+ 3.2	879.0	520.4	2,297.2
24–25	7 a. m. to 1 p. m...	542.2	.....	.....	+ 0.3	214.9	127.2	669.7
	1 p. m. to 7 p. m...	467.2	.....	.....	− 3.0	222.4	131.7	595.9
	7 p. m. to 1 a. m...	443.7	.....	.....	+ 6.1	240.8	142.6	592.4
	1 a. m. to 7 a. m...	239.0	+ .04	+2.4	.....	199.0	117.8	359.2
	Total.....	1,692.1	+ .04	+2.4	+ 3.4	877.1	519.3	2,217.2
25–26	7 a. m. to 1 p. m...	520.2	.....	.....	+ 0.2	214.7	127.1	647.5
	1 p. m. to 7 p. m...	496.7	.....	.....	− 2.2	214.8	127.2	620.7
	7 p. m. to 1 a. m...	430.2	.....	.....	+ 6.6	216.2	128.0	564.8
	1 a. m. to 7 a. m...	270.9	+ .03	+1.8	.....	192.2	113.8	386.5
	Total.....	1,717.0	+ .03	+1.8	+ 4.6	837.9	496.1	2,219.5
	Total, 3 days.	5,183.3	.....	+3.6	+11.2	2,594.0	1,535.8	6,733.9

Balance of income and outgo of matter and energy.—Tables 92–95 summarize the income and outgo of nitrogen, carbon, hydrogen, and energy.

TABLE 92.—*Income and outgo of nitrogen and carbon—Metabolism experiment No. 25.*

Date.	Nitrogen.				Carbon.				
	(*a*) In food.	(*b*) In feces.	(*c*) In urine.	(*d*) Gain (+) or loss (−) $a-(b+c)$.	(*e*) In food.	(*f*) In feces.	(*g*) In urine.	(*h*) In respiratory products.	(*k*) Gain (+) or loss (−) $e-(f+g+h)$.
1900.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Jan. 23–24, 7 a. m. to 7 a. m..	17.7	1.0	16.4	+0.3	270.9	9.7	12.9	218.4	+29.9
24–25, 7 a. m. to 7 a. m..	17.6	.9	16.4	+ .3	270.9	9.6	12.9	216.1	+32.3
25–26, 7 a. m. to 7 a. m..	17.7	1.0	16.4	+ .3	270.9	9.7	12.8	215.3	+33.1
Total, 3 days.....	53.0	2.9	49.2	+ .9	812.7	29.0	38.6	649.8	+95.3
Average, 1 day	17.7	1.0	16.4	+ .3	270.9	9.7	12.9	216.6	+31.7

TABLE 93.—*Income and outgo of water and hydrogen—Metabolism experiment No. 25.*

Date.	Water.					
	(*a*) In food.	(*b*) In drink.	(*c*) In feces.	(*d*) In urine.	(*e*) In respiratory products.	(*f*) Apparent loss, $a+b-(c+d+e)$.
1900.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Jan. 23–24, 7 a. m. to 7 a. m....	1,078	900	48.6	913.1	879.0	+137.3
24–25, 7 a. m. to 7 a. m....	1,078	900	48.6	1,150.0	875.1	− 95.7
25–26, 7 a. m. to 7 a. m....	1,078	900	48.6	1,489.0	836.9	−396.5
Total, 3 days	3,234	2,700	145.8	3,552.1	2,591.0	−354.9
Average, 1 day	1,078	900	48.6	1,184.0	863.7	−118.3

Date.	Hydrogen.					
	(*g*) In food.	(*h*) In feces.	(*i*) In urine.	(*l*) Apparent gain, $g-(h+i)$.	(*m*) Loss from water, $f+9$.	(*n*) Total gain (+) or loss (−), $l+m$.
1900.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Jan. 23–24, 7 a. m. to 7 a. m....	39.7	1.4	3.1	+ 35.2	+15.3	+50.5
24–25, 7 a. m. to 7 a. m....	39.7	1.4	3.1	+ 35.2	−10.6	+24.6
25–26, 7 a. m. to 7 a. m....	39.7	1.5	3.1	+ 35.1	−44.1	− 9.0
Total, 3 days	119.1	4.3	9.3	+105.5	+39.4	+66.1
Average, 1 day	39.7	1.4	3.1	+ 35.2	+13.2	+22.0

TABLE 94.—*Gain or loss of protein ($N \times 6.25$), fat, and water—Metabolism experiment No. 25.*

Date.	(a) Nitrogen gained (+) or lost (−).	(b) Protein gained (+) or lost (−), $a \times 6.25$.	(c) Total carbon gained (+) or lost (−).	(d) Carbon in protein gained (+) or lost (−), $b \times 0.53$.	(e) Carbon in fat, etc., gained (+) or lost (−), $c-d$.	(f) Fat gained (+) or lost (−), $e \div 0.761$.
1900.	*Gram.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Jan. 23–24, 7 a. m. to 7 a. m	+0.3	+1.9	+29.9	+1.0	+28.9	+ 38.0
24–25, 7 a. m. to 7 a. m	+ .3	+1.8	+32.3	+1.0	+31.3	+ 41.1
25–26, 7 a. m. to 7 a. m	+ .3	+1.9	+33.1	+1.0	+32.1	+ 42.2
Total, 3 days	+ .9	+5.6	+95.3	+3.0	+92.3	+121.3
Average, 1 day	+ .3	+1.9	+31.8	+1.0	+30.8	+ 40.4

Date.	(g) Total hydrogen gained (+) or lost (−).	(h) Hydrogen in protein gained (+) or lost (−), $b \times 0.07$.	(i) Hydrogen in fat gained (+) or lost (−), $f \times 0.118$.	(k) Hydrogen in water, etc., gained (+) or lost (−), $g-(h+i)$.	(l) Water gained (+) or lost (−), $k \times 9$.
1900.	*Grams.*	*Gram.*	*Grams.*	*Grams.*	*Grams.*
Jan. 23–24, 7 a. m. to 7 a. m	+50.5	+0.1	+ 4.5	+45.9	+413.1
24–25, 7 a. m. to 7 a. m	+24.6	+ .1	+ 4.8	+19.7	+177.3
25–26, 7 a. m. to 7 a. m	− 9.0	+ .2	+ 5.0	−14.2	−127.8
Total, 3 days	+66.1	+ .4	+14.3	+51.4	+462.6
Average, 1 day	+22.0	+ .1	+ 4.8	+17.1	+154.2

TABLE 95.—*Income and outgo of energy—Metabolism experiment No. 25.*

Date.	(a) Heat of combustion of food eaten.	(b) Heat of combustion of feces.	(c) Heat of combustion of urine.	(d) Estimated heat of combustion of protein gained (+) or lost (−).	(e) Estimated heat of combustion of fat gained (+) or lost (−).	(f) Estimated energy of material oxidized in the body, $a-(b+c+d+e)$.	(g) Heat determined.	(h) Heat determined greater (+) or less (−) than estimated, $g-f$.	(i) Heat determined greater (+) or less (−) than estimated, $h \div f$.
1900.	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Per ct.*
Jan. 23–24, 7 a. m. to 7 a. m	2,896	111	138	+11	+ 362	2,274	2,297	+23	+1.0
24–25, 7 a. m. to 7 a. m	2,896	110	147	+10	+ 392	2,237	2,217	−20	− .9
25–26, 7 a. m. to 7 a. m	2,896	111	155	+11	+ 403	2,216	2,220	+ 4	+ .2
Total, 3 days	8,688	332	440	+32	+1,157	6,727	6,734	+ 7	+ .3
Average, 1 day	2,896	111	147	+11	+ 385	2,242	2,244	+ 2	+ .1

METABOLISM EXPERIMENTS NOS. 26 AND 28.

Subject.—J. F. S., as in the previous experiment, weighing with underclothing about 64 kilograms (141 pounds).

Occupation during experiment.—Reading, writing, and miscellaneous observations within the apparatus, with as little muscular activity as practicable.

Duration.—Experiments Nos. 26 and 28 form the first and last of a series of 3 experiments which were made for the purpose of studying the relative replacing power of isodynamic amounts of different materials; the intermediate experiment is not reported here. The usual preliminary period of 4 days duration began with breakfast February 10, 1900, and ended with supper February 13. The subject entered the calorimeter on the evening of February 13 and experiment No. 26 began at 7 a. m. February 14, continuing 3 days. Experiment No. 28 began at 7 a. m. February 20, and continued until 7 a. m. February 23.

Diet.—The diet consisted of a basal ration furnishing about 99 grams of protein and 1,982 calories of energy per day. To this, in experiment No. 26, was added 63.5 grams of butter, furnishing 1 gram of protein and 508 calories of energy. In experiment No. 28 the material added consisted of 128 grams of cane sugar, furnishing 507 calories of energy per day. The protein and energy were thus practically the same in both of the experiments. The kinds and quantities of food in the basal ration as served for each meal, the character and amount of the supplemental ration in the different experiments, and the quantity of drink consumed at different periods of the day in each experiment were as follows:

TABLE 96.—*Diet in metabolism experiments Nos. 26 and 28.*

FOOD—BASAL RATION.

Food materials.	Breakfast.	Dinner.	Supper.	Total.
	Grams.	*Grams.*	*Grams.*	*Grams.*
Beef	35	50	.....	85
Butter	10	12	8	30
Milk	300	400	300	1,000
Bread	50	100	50	200
Ginger snaps	.....	30	30	60
Parched cereal	25	.....	25	50
Sugar	15	.....	.....	15

FOOD—SUPPLEMENTAL RATION.

Experiment No. 26	63.5 grams butter per day.
Experiment No. 28	128 grams sugar per day.

DRINK.

Time.	Water.	Time.	Water.
	Grams.		*Grams.*
Breakfast	100	9 p. m	300
10 a. m	200	Total for day	800
3 p. m	200		

Daily routine.—The general routine of the experiment was as follows:

TABLE 97.—*Daily programme—Metabolism experiments Nos. 26 and 28.*

6.50 a. m	Take pulse and temperature.	6.00 p. m	Supper.
7.00 a. m	Rise, pass urine, weigh self, weigh absorbers.	6.50 p. m	Take pulse and temperature.
		7.00 p. m	Pass urine, weigh self, weigh absorbers.
7.45 a. m	Breakfast, drink 100 grams water.		
10.00 a. m	Drink 200 grams water.	9.00 p. m	Drink 300 grams water.
12.50 p. m	Take pulse and temperature.	10.20 p. m	Take pulse and temperature.
1.00 p. m	Pass urine.	10.30 p. m	Retire.
1.15 p. m	Dinner.	1.00 a. m	Pass urine.
3.00 p. m	Drink 200 grams water.		

The more important statistics in the diary kept by the subject during experiments Nos. 26 and 28 are summarized in Table 98.

TABLE 98.—*Summary of the diary—Metabolism experiments Nos. 26 and 28.*

Time.	Weight of subject in underclothes.	Pulse rate per minute.	Temperature.	Time.	Weight of subject in underclothes.	Pulse rate per minute.	Temperature.
1900.				1890.			
Experiment No. 26.	*Kgs.*		°*F.*	*Expt. No. 26*—Cont'd.	*Kgs.*		°*F.*
Feb. 14, 7.00 a. m	64	68	97.8	Feb. 15, 5.30 p. m	.....	.....	98.0
8.36 a. m	.....	78	98.3	5.49 p. m	.....	69	.....
10.27 a. m	.....	67	98.1	6.30 p. m	.....	69	98.2
12.27 p. m	.....	64	.....	6.55 p. m	64.87	68	98.2
12.33 p. m	.....	.....	97.8	7.30 p. m	.....	75	98.1
12.53 p. m	.....	61	.....	8.30 p. m	.....	67	97.6
1.00 p. m	.....	.....	97.9	8.54 p. m	.....	70	.....
2.27 p. m	.....	77	98.5	9.00 p. m	.....	.....	97.5
3.47 p. m	.....	.....	98.5	9.30 p. m	.....	67	.....
4.30 p. m	.....	72	98.5	9.35 p. m	.....	.....	97.4
5.30 p. m	.....	67	.....	9.51 p. m	.....	.....	97.6
5.45 p. m	.....	.....	98.7	10.15 p. m	.....	70	.....
6.17 p. m	64.88	.....	.....	10.20 p. m	.....	.....	97.5
8.13 p. m	.....	.....	97.6	Feb. 16, 6.55 a. m	.....	71	.....
8.30 p. m	.....	64	97.5	7.00 a. m	64.01	.....	98.1
9.29 p. m	.....	64	97.7	8.32 a. m	.....	82	.....
10.15 p. m	.....	64	.....	8.40 a. m	.....	.....	98.3
Feb. 15, 6.50 a. m	.....	69	98.1	9.30 a. m	.....	79	.....
7.00 a. m	64.18	.....	.....	9.37 a. m	.....	.....	98.2
7.34 a. m	.....	78	.....	10.31 a. m	.....	76	98.3
7.39 a. m	.....	.....	98.3	11.26 a. m	.....	72	.....
8.33 a. m	.....	82	98.5	11.30 a. m	.....	.....	98.2
9.28 a. m	.....	80	.....	12.27 p. m	.....	70	.....
9.30 a. m	.....	.....	98.3	12.30 p. m	.....	.....	98.1
10.33 a. m	.....	71	.....	12.58 p. m	.....	71	.....
10.46 a. m	.....	.....	98.5	1.00 p. m	.....	.....	98.2
11.30 a. m	.....	70	98.1	2.01 p. m	.....	80	98.2
12.31 p. m	.....	68	.....	2.30 p. m	.....	79	98.2
12.37 p. m	.....	.....	98.4	3.35 p. m	.....	81	98.3
12.54 p. m	.....	68	.....	4.05 p. m	.....	.....	98.2
1.00 p. m	.....	.....	98.2	4.27 p. m	.....	79	.....
1.59 p. m	.....	75	98.2	4.30 p. m	.....	.....	98.2
2.28 p. m	.....	81	98.5	5.30 p. m	.....	75	98.5
3.35 p. m	.....	77	98.2	5.43 p. m	.....	.....	98.7
4.28 p. m	.....	76	.....	6.32 p. m	.....	80	.....
4.30 p. m	.....	.....	98.1	6.42 p. m	.....	.....	98.4

TABLE 98.—*Summary of the diary—Metabolism experiments Nos. 26 and 28*—Continued.

Time.	Weight of subject in underclothes.	Pulse rate per minute.	Temperature.
1900.			
Experiment No. 26.	*Kgs.*		°*F.*
Feb. 16, 7.00 p. m.	64.73	77	98.5
7.34 p. m.	.....	75	.....
7.40 p. m.	.....	.....	98
7.50 p. m.	.....	.....	98.3
8.26 p. m.	.....	71	.....
8.30 p. m.	.....	.....	97.8
9.31 p. m.	.....	68	97.8
Experiment No. 28.			
Feb. 20, 6.55 a. m.	.....	72	.....
7.00 a. m.	63.71	.....	98.1
7.32 a. m.	.....	88	.....
7.35 a. m.	.....	.....	98.4
8.30 a. m.	.....	91	.....
8.31 a. m.	.....	.....	98.4
9.30 a. m.	.....	99	98.7
10.30 a. m.	.....	84	98.4
11.30 a. m.	.....	81	98.2
11.36 a. m.	.....	78	.....
12.27 p. m.	.....	70	.....
12.33 p. m.	.....	.....	98.1
12.57 p. m.	.....	70	.....
12.59 p. m.	.....	.....	98.1
1.52 p. m.	.....	81	.....
1.57 p. m.	.....	.....	98.3
3.34 p. m.	.....	81	98.2
4.30 p. m.	.....	79	98.1
5.32 p. m.	.....	71	.....
5.41 p. m.	.....	.....	98
6.35 p. m.	.....	77	.....
6.40 p. m.	.....	.....	98.1
6.57 p. m.	.....	78	.....
7.00 p. m.	64.32	.....	98.1
7.30 p. m.	.....	88	97.8
8.28 p. m.	.....	72	.....
8.30 p. m.	.....	.....	97.7
9.30 p. m.	.....	67	.....
9.32 p. m.	.....	.....	97.3
10.18 p. m.	.....	67	.....
10.20 p. m.	.....	.....	97.2
Feb. 21, 6.55 a. m.	.....	73	.....
7.00 a. m.	63.83	.....	98.1
7.29 a. m.	.....	87	.....
7.30 a. m.	.....	.....	98.1
8.29 a. m.	.....	92	.....
8.30 a. m.	.....	.....	98.3
9.30 a. m.	.....	101	98.3
10.30 a. m.	.....	87	.....
10.33 a. m.	.....	.....	98.4
11.27 a. m.	.....	78	.....
11.31 a. m.	.....	.....	97.9
12.31 p. m.	.....	77	98.1
1.00 p. m.	.....	73	.....

Time.	Weight of subject in underclothes.	Pulse rate per minute.	Temperature.
1900.			
Expt. No. 28—Cont'd.	*Kgs.*		°*F.*
Feb. 21, 1.54 p. m.	.....	80	.....
2.01 p. m.	.....	.....	98.2
2.27 p. m.	.....	93	.....
2.34 p. m.	.....	.....	98.5
3.52 p. m.	.....	86	.....
3.54 p. m.	.....	.....	98.2
4.35 p. m.	.....	76	.....
4.52 p. m.	.....	79	98.2
5.28 p. m.	.....	75	98.5
6.32 p. m.	.....	77	.....
6.59 p. m.	.....	79	98.2
7.00 p. m.	64.63	.....	.....
7.31 p. m.	.....	81	97.7
7.41 p. m.	.....	.....	97.9
8.27 p. m.	.....	79	.....
8.30 p. m.	.....	.....	97.7
9.27 p. m.	.....	73	.....
9.52 p. m.	.....	.....	97.6
Feb. 22, 6.55 a. m.	.....	69	.....
7.00 a. m.	63.85	.....	98.1
7.36 a. m.	.....	85	.....
7.40 a. m.	.....	.....	97.9
8.28 a. m.	.....	93	.....
8.33 a. m.	.....	.....	98.3
9.27 a. m.	.....	95	.....
9.30 a. m.	.....	.....	98.2
10.29 a. m.	.....	87	.....
10.30 a. m.	.....	.....	98.4
11.36 a. m.	.....	82	98.0
12.27 p. m.	.....	74	.....
12.30 p. m.	.....	.....	98.2
12.55 p. m.	.....	70	.....
12.58 p. m.	.....	.....	98.2
2.07 p. m.	.....	83	.....
2.15 p. m.	.....	.....	98.6
2.30 p. m.	.....	84	.....
2.50 p. m.	.....	.....	98.4
3.30 p. m.	.....	84	98.4
4.29 p. m.	.....	78	98.4
5.30 p. m.	.....	73	.....
5.37 p. m.	.....	.....	98.2
6.30 p. m.	.....	73	98.4
6.57 p. m.	64.77	76	98.1
7.27 p. m.	.....	74	.....
7.31 p. m.	.....	.....	97.7
8.32 p. m.	.....	72	.....
8.42 p. m.	.....	.....	97.5
9.27 p. m.	.....	66	.....
9.30 p. m.	.....	.....	97.3
10.20 p. m.	.....	70	97.1
Feb. 23, 6.55 a. m.	.....	76	.....
7.00 a. m.	64.05	.....	98.1

Detailed data of income and outgo.—The quantities of nutrients in the basal ration which were used for the experiments and the quantities in the supplemental ration in the two experiments are shown in Table 99. The elimination of matter and energy in the feces was determined in each experiment and the results are recorded in Table 100.

TABLE 99.—*Weight, composition, and heat of combustion of foods—Metabolism experiments Nos. 26 and 28.*

Laboratory No.	Food materials.	Weight per day.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
3176	Beef	85.0	53.1	28.7	2.4	.....	4.60	16.62	2.30	187
3177	Butter	30.0	3.0	.5	25.8	.....	.08	19.51	3.01	240
3179	Milk, skimmed	1,000.0	900.0	42.0	3.0	47.0	6.70	46.30	6.30	462
3180	Bread	200.0	78.6	17.8	3.2	97.8	2.84	55.52	7.98	561
3181	Ginger snaps	60.0	2.5	3.7	5.0	47.9	.60	26.59	3.97	266
3168	Parched cereal	50.0	2.8	5.9	.9	39.5	.94	21.10	2.97	207
.....	Sugar	15.0	.....	.....	.....	15.0	.....	6.31	.97	59
	Total basal ration	1,440.0	1,040.0	98.6	40.3	247.2	15.76	191.95	27.50	1,982
	EXPERIMENT NO. 26.									
3177	Butter (supplemental ration)	63.5	6.3	1.0	54.5	.....	.16	41.29	6.36	508
	Total ration, 1 day.	**1,503.5**	**1,046.3**	**99.6**	**94.8**	**247.2**	**15.92**	**233.24**	**33.86**	**2,490**
	EXPERIMENT NO. 28.									
	Total basal ration	1,440.0	1,040.0	98.6	40.3	247.2	15.76	191.95	27.50	1,982
.....	Sugar (supplemental ration)	128.0	.....	.....	.....	128.0	.....	53.88	8.29	507
	Total ration, 1 day.	**1,568.0**	**1,040.0**	**98.6**	**40.3**	**375.2**	**15.76**	**245.83**	**35.79**	**2,489**

TABLE 100.—*Weight, composition, and heat of combustion of feces—Metabolism experiments Nos. 26 and 28.*

Laboratory No.		Weight of feces.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
	Experiment No. 26.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
3183	Total, 3 days	236.5	171.0	20.6	8.5	20.1	3.26	28.33	3.41	317
	Average, 1 day	78.8	57.0	6.9	2.8	6.7	1.09	9.44	1.14	106
	Experiment No. 28.									
3185	Total, 3 days	219.9	155.2	23.3	12.1	16.1	3.74	29.93	4.02	335
	Average, 1 day	73.3	51.7	7.8	4.0	5.3	1.25	9.98	1.34	112

The usual statistics of outgo of nitrogen, carbon, hydrogen, water, and energy in the urine are given in Tables 101 and 102. The urine was collected in the usual periods for twenty-four hours following the close of experiment No. 28. The elimination of nitrogen in these periods was 3.48, 5.25, 4.74, and 2.96 grams, respectively, or a total of 16.43 grams.

TABLE 101.—*Amount, specific gravity, and nitrogen of urine—Metabolism experiments Nos. 26 and 28.*

Date.	Period.	Amount of urine.	Specific gravity.	Nitrogen content.	
1900.	*Experiment No. 26.*	*Grams.*		*Per cent.*	*Grams.*
Feb. 14–15	7 a. m. to 1 p. m	326.7	1.0225	1.31	4.28
	1 p. m. to 7 p. m	297.6	1.0245	1.57	4.67
	7 p. m. to 1 a. m	264.8	1.0225	1.54	4.08
	1 a. m. to 7 a. m	327.4	1.017	1.10	3.60
	Total	1,216.5			16.63
	Total by composite	1,216.5	1.021	1.38	16.78
15–16	7 a. m. to 1 p. m	451.4	1.017	.83	3.75
	1 p. m. to 7 p. m	356.7	1.021	1.23	4.39
	7 p. m. to 1 a. m	274.3	1.021	1.35	3.70
	1 a. m. to 7 a. m	443.7	1.0115	.73	3.24
	Total	1,526.1			15.08
	Total by composite	1,526.1	1.0175	.99	15.11
16–17	7 a. m. to 1 p. m	381.6	1.0185	.91	3.47
	1 p. m. to 7 p. m	400.2	1.0185	1.04	4.16
	7 p. m. to 1 a. m	266.2	1.020	1.35	3.59
	1 a. m. to 7 a. m	292.4	1.017	1.10	3.22
	Total	1,340.4			14.44
	Total by composite	1,340.4	1.0185	1.09	14.61
	Total, 3 days, by periods	4,083.0			46.15
	Total by composite	4,083.0			46.00
	Experiment No. 28.				
Feb. 20–21	7 a. m. to 1 p. m	379.2	1.0185	1.12	4.25
	1 p. m. to 7 p. m	327.3	1.021	1.39	4.55
	7 p. m. to 1 a. m	207.1	1.0255	1.82	3.77
	1 a. m. to 7 a. m	256.2	1.018	1.30	3.33
	Total	1,169.8			15.90
	Total by composite	1,169.8	1.020	1.37	16.03
21–22	7 a. m. to 1 p. m	340.7	1.018	1.09	3.71
	1 p. m. to 7 p. m	267.7	1.024	1.60	4.28
	7 p. m. to 1 a. m	276.8	1.020	1.41	3.90
	1 a. m. to 7 a. m	407.0	1.011	.82	3.34
	Total	1,292.2			15.23
	Total by composite	1,292.2	1.017	1.19	15.38
22–23	7 a. m. to 1 p. m	302.8	1.0185	1.11	3.36
	1 p. m. to 7 p. m	258.5	1.023	1.58	4.08
	7 p. m. to 1 a. m	234.7	1.022	1.62	3.80
	1 a. m. to 7 a. m	406.5	1.012	.84	3.41
	Total	1,202.5			14.65
	Total by composite	1,202.5	1.018	1.23	14.79
	Total, 3 days, by periods	3,664.5			45.78
	Total by composite	3,664.5			46.20
	Total, 9 days,[a] by composite	11,998.8	1.019	1.19	138.84

[a] Including 3 days of an experiment not here reported.

TABLE 102.—*Daily elimination of carbon, hydrogen, water, and energy in urine—Metabolism experiments Nos. 26 and 28.*

Date.	Period.	Amount of urine.	Carbon.		Hydrogen.		Water.		Heat of combustion.	
									Per gram.	Total.
1900.	*Experiment No. 26.*	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*Calorie.*	*Calories*
Feb. 14–15	7 a. m. to 7 a. m...	1,216.5	.....	11.93	.....	2.87	.....	1,157.3	0.103	125
15–16	7 a. m. to 7 a. m...	1,526.1	.....	10.82	.....	2.61	.....	1,472.4	.082	125
16–17	7 a. m. to 7 a. m...	1,340.4	.....	10.36	.....	2.50	.....	1,289.0	.101	135
	Total, 3 days..	4,083.0	.....	33.11	.....	7.98	.....	3,918.7	.....	385
	Experiment No. 28.									
Feb. 20–21	7 a. m. to 7 a. m...	1,169.8	.....	11.40	.....	2.75	.....	1,113.2	.102	119
21–22	7 a. m. to 7 a. m...	1,292.2	.....	10.92	.....	2.63	.....	1,238.0	.103	133
22–23	7 a. m. to 7 a. m...	1,202.5	.....	10.51	.....	2.53	.....	1,150.3	.110	132
	Total, 3 days..	3,664.5	.....	32.83	.....	7.91	.....	3,501.5	.....	384
	Total, 9 days[a].	11,998.8	0.83	99.59	0.20	24.00	95.88	11,504.5	.095	1,141

[a] This period includes the 6 days of experiments Nos. 26 and 28 and 3 days of an intervening experiment not reported here.

Tables 103–105 show the quantities of carbon dioxid and water found in the ventilating air current in these two experiments.

TABLE 103.—*Comparison of residual amounts of carbon dioxid and water in the chamber at the beginning and end of each period, and the corresponding gain or loss—Metabolism experiments Nos. 26 and 28.*

Date.	End of period.	Carbon dioxid.		Water.		
		Total amount in chamber.	Gain (+) or loss (−) over preceding period.	Total amount of vapor remaining in chamber.	Gain (+) or loss (−) over preceding period.	Total amount gained (+) or lost (−) during the period.[a]
1900.	*Experiment No. 26.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Feb. 14	7 a. m	22.2	.....	36.3	.....	.....
14	1 p. m	32.3	+10.1	36.9	+ 0.6	+ 0.6
14	7 p. m	35.7	+ 3.4	38.4	+ 1.5	+ 1.5
15	1 a. m	22.8	−12.9	35.5	− 2.9	− 2.9
15	7 a. m	25.3	+ 2.5	33.6	− 1.9	− 1.9
	Total	.....	+ 3.1	.....	− 2.7	− 2.7
15	1 p. m	34.4	+ 9.1	37.4	+ 3.8	+ 3.8
15	7 p. m	34.8	+ 0.4	36.9	− 0.5	− 0.5
16	1 a. m	24.1	−10.7	34.8	− 2.1	− 2.1
16	7 a. m	22.6	− 1.5	32.3	− 2.5	− 2.5
	Total	.....	− 2.7	.....	− 1.3	− 1.3
16	1 p. m	30.8	+ 8.2	35.9	+ 3.6	+ 3.6
16	7 p. m	39.5	+ 8.7	38.8	+ 2.9	+ 2.9
17	1 a. m	21.5	−18.0	34.4	− 4.4	− 4.4
17	7 a. m	23.0	+ 1.5	31.4	− 3.0	− 3.0
	Total	.....	+ 0.4	.....	− 0.9	− 0.9
	Experiment No. 28.					
Feb. 20	7 a. m	26.4	.....	32.9	.....	.....
20	1 p. m	35.2	+ 8.8	39.9	+ 7.0	+ 7.0
20	7 p. m	37.2	+ 2.0	40.1	+ 0.2	+ 0.2
21	1 a. m	24.1	−13.1	34.8	− 5.3	− 5.3
21	7 a. m	24.1	0	30.8	− 4.0	− 4.0
	Total	.....	− 2.3	.....	− 2.1	− 2.1
21	1 p. m	38.0	+13.9	40.3	+ 9.5	+ 9.5
21	7 p. m	19.0	−19.0	30.2	−10.1	−10.1
22	1 a. m	26.4	+ 7.4	36.1	+ 5.9	+ 5.9
22	7 a. m	28.9	+ 2.5	35.5	− 0.6	− 0.6
	Total	.....	+ 4.8	.....	+ 4.7	+ 4.7
22	1 p. m	36.7	+ 7.8	38.8	+ 3.3	+ 3.3
22	7 p. m	39.7	+ 3.0	39.3	+ 0.5	+ 0.5
23	1 a. m	26.0	−13.7	36.5	− 2.8	− 2.8
23	7 a. m	28.7	+ 2.7	33.4	− 3.1	− 3.1
	Total	.....	− 0.2	.....	− 2.1	− 2.1

[a] The differences in weight of the absorbers were so small as to be within the limit of error of the weighing apparatus. There was no drip.

TABLE 104.—*Record of carbon dioxid in ventilating air current—Metabolism experiments Nos. 26 and 28.*

Date.	Period.	(a) Ventilation (number of liters of air).	Carbon dioxid. In incoming air. (b) Per liter.	(c) Total, $a \times b$.	(d) In outgoing air.	(e) Total excess in outgoing air, $d - c$.	(f) Correction for amount remaining in chamber.	(g) Corrected amount exhaled by subject, $e + f$.	(h) Total weight of carbon exhaled, $g \times \frac{3}{11}$.
1900.	*Experiment No. 26.*	*Liters.*	*Mg.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Feb. 14–15	7 a. m. to 1 p. m	28,762	0.529	15.2	212.1	196.9	+10.1	207.0	56.5
	1 p. m. to 7 p. m	28,762	.568	16.3	215.9	199.6	+ 3.4	203.0	55.4
	7 p. m. to 1 a. m	30,316	.568	17.2	204.1	186.9	−12.9	174.0	47.4
	1 a. m. to 7 a. m	28,762	.555	16.0	144.2	128.2	+ 2.5	130.7	35.6
	Total	116,602	.....	64.7	776.3	711.6	+ 3.1	714.7	194.9
15–16	7 a. m. to 1 p. m	27,985	.556	15.6	220.0	204.4	+ 9.1	213.5	58.2
	1 p. m. to 7 p. m	29,541	.561	16.6	226.7	210.1	+ .4	210.5	57.4
	7 p. m. to 1 a. m	30,316	.550	16.7	204.0	187.3	−10.7	176.6	48.2
	1 a. m. to 7 a. m	30,316	.555	16.8	145.2	128.4	− 1.5	126.9	34.6
	Total	118,158	.....	65.7	795.9	730.2	− 2.7	727.5	198.4
16–17	7 a. m. to 1 p. m	29,540	.582	17.2	209.2	192.0	+ 8.2	200.2	54.6
	1 p. m. to 7 p. m	30,316	.571	17.3	225.4	208.1	+ 8.7	216.8	59.1
	7 p. m. to 1 a. m	29,540	.551	16.3	202.6	186.3	−18.0	168.3	45.9
	1 a. m. to 7 a. m	30,316	.559	16.9	144.8	127.9	+ 1.5	129.4	35.3
	Total	119,712	.....	67.7	782.0	714.3	+ .4	714.7	194.9
	Total, 3 days .	354,472	.....	198.1	2,354.2	2,156.1	+ .8	2,156.9	588.2
	Experiment No. 28.								
Feb. 20–21	7 a. m. to 1 p. m	27,985	.572	16.0	240.0	224.0	+ 8.8	232.8	63.5
	1 p. m. to 7 p. m	27,208	.576	15.7	231.6	215.9	+ 2.0	217.9	59.4
	7 p. m. to 1 a. m	28,762	.578	16.6	214.1	197.5	−13.1	184.4	50.3
	1 a. m. to 7 a. m	28,762	.557	16.0	154.6	138.6	0	138.6	37.8
	Total	112,717	.....	64.3	840.3	776.0	− 2.3	773.7	211.0
21–22	7 a. m. to 1 p. m	26,430	.640	16.9	229.6	212.7	+13.9	226.6	61.8
	1 p. m. to 7 p. m	27,208	.637	17.3	235.5	218.2	−19.0	199.2	54.3
	7 p. m. to 1 a. m	28,762	.597	17.2	227.6	210.4	+ 7.4	217.8	59.4
	1 a. m. to 7 a. m	26,430	.612	16.2	150.6	134.4	+ 2.5	136.9	37.3
	Total	108,830	.....	67.6	843.3	775.7	+ 4.8	780.5	212.8
22–23	7 a. m. to 1 p. m	26,430	.614	16.2	231.0	214.8	+ 7.8	222.6	60.7
	1 p. m. to 7 p. m	27,208	.609	16.6	225.0	208.4	+ 3.0	211.4	57.6
	7 p. m. to 1 a. m	28,762	.560	16.1	220.2	204.1	−13.7	190.4	51.9
	1 a. m. to 7 a. m	28,762	.609	17.5	154.4	136.9	+ 2.7	139.6	38.1
	Total	111,162	.....	66.4	830.6	764.2	− .2	764.0	208.3
	Total, 3 days .	332,709	.....	198.3	2,514.2	2,315.9	+ 2.3	2,318.2	632.1

TABLE 105.—*Record of water in ventilating air current—Metabolism experiments Nos. 26 and 28.*

Date.	Period.	(a) Ventilation (number of liters of air).	Water in incoming air. (b) Per liter.	Water in incoming air. (c) Total, a×b.	Water in outgoing air. (d) Amount condensed in freezers.	Water in outgoing air. (e) Amount not condensed in freezers.	Water in outgoing air. (f) Total, d+e.	(g) Total excess water in outgoing air, f−c.	(h) Correction for water remaining in chamber.	(i) Total water of respiration and perspiration, g+h.
1900.	*Experiment No.26.*	*Liters.*	*Mg.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Feb. 14–15	7 a. m. to 1 p. m.	28,762	0.816	23.5	197.3	47.6	244.9	221.4	+ 0.6	222.0
	1 p. m. to 7 p. m.	28,762	.852	24.5	196.1	42.2	238.3	213.8	+ 1.5	215.3
	7 p. m. to 1 a. m.	30,316	.828	25.1	184.6	49.0	233.6	208.5	− 2.9	205.6
	1 a. m. to 7 a. m.	28,762	.833	24.0	171.3	40.8	212.1	188.1	− 1.9	186.2
	Total	116,602	.....	97.1	749.3	179.6	928.9	831.8	− 2.7	829.1
15–16	7 a. m. to 1 p. m.	27,985	.867	24.3	179.7	42.7	222.4	198.1	+ 3.8	201.9
	1 p. m. to 7 p. m.	29,541	.890	26.3	195.0	43.0	238.0	211.7	− .5	211.2
	7 p. m. to 1 a. m.	30,316	.860	26.1	185.5	47.6	233.1	207.0	− 2.1	204.9
	1 a. m. to 7 a. m.	30,316	.828	25.1	174.1	42.1	216.2	191.1	− 2.5	188.6
	Total	118,158	.....	101.8	734.3	175.4	909.7	807.9	− 1.3	806.6
16–17	7 a. m. to 1 p. m.	29,540	.828	24.5	182.3	44.7	227.0	202.5	+ 3.6	206.1
	1 p. m. to 7 p. m.	30,316	.820	24.9	188.8	43.0	231.8	206.9	+ 2.9	209.8
	7 p. m. to 1 a. m.	29,540	.824	24.3	184.9	45.2	230.1	205.8	− 4.4	201.4
	1 a. m. to 7 a. m.	30,316	.795	24.1	168.9	40.4	209.3	185.2	− 3.0	182.2
	Total	119,712	.....	97.8	724.9	173.3	898.2	800.4	− .9	799.5
	Total, 3 days	354,472	.....	296.7	2,208.5	528.3	2,736.8	2,440.1	− 4.9	2,435.2
	Experiment No.28.									
Feb. 20–21	7 a. m. to 1 p. m.	27,985	.836	23.4	204.6	43.7	248.3	224.9	+ 7.0	231.9
	1 p. m. to 7 p. m.	27,208	.845	23.0	203.6	37.6	241.2	218.2	+ .2	218.4
	7 p. m. to 1 a. m.	28,762	.850	24.4	191.4	43.1	234.5	210.1	− 5.3	204.8
	1 a. m. to 7 a. m.	28,762	.836	24.0	170.2	39.3	209.5	185.5	− 4.0	181.5
	Total	112,717	.....	94.8	769.8	163.7	933.5	838.7	− 2.1	836.6
21–22	7 a. m. to 1 p. m.	26,430	.848	22.4	186.4	38.9	225.3	202.9	+ 9.5	212.4
	1 p. m. to 7 p. m.	27,208	.806	21.9	201.4	38.2	239.6	217.7	−10.1	207.6
	7 p. m. to 1 a. m.	28,762	.867	24.9	187.9	43.9	231.8	206.9	+ 5.9	212.8
	1 a. m. to 7 a. m.	26,430	.796	21.0	166.7	35.9	202.6	181.6	− .6	181.0
	Total	108,830	.....	90.2	742.4	156.9	899.3	809.1	+ 4.7	813.8
22–23	7 a. m. to 1 p. m.	26,430	.899	23.8	185.2	39.2	224.4	200.6	+ 3.3	203.9
	1 p. m. to 7 p. m.	27,208	.890	24.2	194.8	37.4	232.2	208.0	+ .5	208.5
	7 p. m. to 1 a. m.	28,762	.917	26.4	183.7	43.9	227.6	201.2	− 2.8	198.4
	1 a. m. to 7 a. m.	28,762	.816	23.5	167.0	39.4	206.4	182.9	− 3.1	179.8
	Total	111,162	.....	97.9	730.7	159.9	890.6	792.7	− 2.1	790.6
	Total, 3 days	332,709	.....	282.9	2,242.9	480.5	2,723.4	2,440.5	− .5	2,441.0

The heat carried away by the water current and the latent heat of vaporization of water in experiments Nos. 26 and 28 are shown in Table 106.

TABLE 106.—*Summary of calorimetric measurements—Metabolism experiments Nos. 26 and 28.*

Date.	Period.	(a) Heat measured in terms of C_{20}.	(b) Change of temperature of calorimeter.	(c) Capacity correction of calorimeter, $b \times 60$.	(d) Correction due to temperature of food and dishes.	(e) Water vaporized equals total amount exhaled less amount condensed in chamber.	(f) Heat used in vaporization of water, $e \times 0.592$.	(g) Total heat determined, $a+c+d+f$.
1900.	*Experiment No. 26.*	*Calories.*	*Degree.*	*Calories.*	*Calories.*	*Grams.*	*Calories.*	*Calories.*
Feb. 14–15	7 a. m. to 1 p. m ..	525.5	−0.2	−1.2	− 2.1	222.0	131.4	653.6
	1 p. m. to 7 p. m ..	453.2	− .1	− .6	− 3.9	215.3	127.5	576.2
	7 p. m. to 1 a. m ..	350.9	− .1	− .6	+ 7.7	205.6	121.7	479.7
	1 a. m. to 7 a. m...	254.5	+ .5	+3.0	0	186.2	110.2	367.7
	Total.....	1,584.1	+ .1	+ .6	+ 1.7	829.1	490.8	2,077.2
15–16	7 a. m. to 1 p. m ..	522.8	0	0	+ .2	201.9	119.5	642.5
	1 p. m. to 7 p. m ..	465.5	− .1	− .6	− 3.8	211.2	125.0	586.1
	7 p. m. to 1 a. m ..	388.2	+ .1	+ .6	+ 6.1	204.9	121.3	516.2
	1 a. m. to 7 a. m...	241.8	+ .3	+1.8	0	188.6	111.7	355.3
	Total.....	1,618.3	+ .3	+1.8	+ 2.5	806.6	477.5	2,100.1
16–17	7 a. m. to 1 p. m ..	510.7	0	0	+ 3.1	206.1	122.0	635.8
	1 p. m. to 7 p. m ..	468.9	0	0	− .7	209.8	124.2	592.4
	7 p. m. to 1 a. m ..	371.4	+ .1	+ .6	+ 9.6	201.4	119.2	500.8
	1 a. m. to 7 a. m...	241.3	0	0	0	182.2	107.9	349.2
	Total.....	1,592.3	+ .1	+0.6	+12.0	799.5	473.3	2,078.2
	Total, 3 days.	4,794.7	.....	+3.0	+16.2	2,435.2	1,441.6	6,255.5
	Experiment No. 28.							
Feb. 20–21	7 a. m. to 1 p. m ..	526.0	0	0	− .3	231.9	137.3	663.0
	1 p. m. to 7 p. m ..	472.5	0	0	− .8	218.4	129.3	601.0
	7 p. m. to 1 a. m ..	361.9	− .3	−1.8	+ 3.9	204.8	121.2	485.2
	1 a. m. to 7 a. m...	239.1	+ .3	+1.8	.....	181.5	107.4	348.3
	Total.....	1,599.5	0	0	+ 2.8	836.6	495.2	2,097.5
21–22	7 a. m. to 1 p. m ..	501.0	0	0	+ 2.1	212.4	125.7	628.8
	1 p. m. to 7 p. m ..	441.5	0	0	− 3.6	207.6	122.9	560.8
	7 p. m. to 1 a. m ..	393.6	+ .2	+1.2	+ 4.1	212.8	126.0	524.9
	1 a. m. to 7 a. m...	253.6	0	0	.....	181.0	107.2	360.8
	Total.....	1,589.7	+ .2	+1.2	+ 2.6	813.8	481.8	2,075.3
22–23	7 a. m. to 1 p. m ..	507.7	0	0	+ 1.0	203.9	120.7	629.4
	1 p. m. to 7 p. m ..	456.2	0	0	− 7.0	208.5	123.4	572.6
	7 p. m. to 1 a. m ..	378.6	+ .1	+0.6	+ 8.2	198.4	117.5	504.9
	1 a. m. to 7 a. m ..	251.7	0	0	.....	179.8	106.4	358.1
	Total.....	1,594.2	+ .1	+0.6	+ 2.2	790.6	468.0	2,065.0
	Total, 3 days.	4,783.4	.....	+1.8	+ 7.6	2,441.0	1,445.0	6,237.8

Balance of income and outgo of matter and energy.—Tables 107–110 summarize the income and outgo of nitrogen, carbon, hydrogen, and energy in this series of experiments.

TABLE 107.—*Income and outgo of nitrogen and carbon—Metabolism experiments Nos. 26 and 28.*

Date.	Nitrogen.				Carbon.				
	(*a*) In food.	(*b*) In feces.	(*c*) In urine.	(*d*) Gain (+) or loss (−), $a-(b+c)$.	(*e*) In food.	(*f*) In feces.	(*g*) In urine.	(*h*) In respiratory products.	(*k*) Gain (+) or loss (−), $e-(f+g+h)$.
1900.									
Experiment No. 26.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Feb. 14–15, 7 a. m. to 7 a. m..	15.9	1.1	16.6	−1.8	233.2	9.4	11.9	194.9	+17.0
15–16, 7 a. m. to 7 a. m..	15.9	1.1	15.1	−0.3	233.2	9.5	10.8	198.4	+14.5
16–17, 7 a. m. to 7 a. m..	15.9	1.1	14.4	+0.4	233.2	9.4	10.4	194.9	+18.5
Total, 3 days.....	47.7	3.3	46.1	−1.7	699.6	28.3	33.1	588.2	+50.0
Average, 1 day	15.9	1.1	15.4	−0.6	233.2	9.4	11.0	196.1	+16.7
Experiment No. 28.									
Feb. 20–21, 7 a. m. to 7 a. m..	15.8	1.2	15.9	−1.3	245.8	10.0	11.4	211.0	+13.4
21–22, 7 a. m. to 7 a. m..	15.7	1.3	15.2	−0.8	245.8	10.0	10.9	212.8	+12.1
22–23, 7 a. m. to 7 a. m..	15.8	1.2	14.7	−0.1	245.8	10.0	10.5	208.3	+17.0
Total, 3 days.....	47.3	3.7	45.8	−2.2	737.4	30.0	32.8	632.1	+42.5
Average, 1 day	15.8	1.2	15.3	−0.7	245.8	10.0	10.9	210.7	+14.2

TABLE 108.—*Income and outgo of water and hydrogen—Metabolism experiments Nos. 26 and 28.*

Date.	Water.					
	(*a*) In food.	(*b*) In drink.	(*c*) In feces.	(*d*) In urine.	(*e*) In respiratory products.	(*f*). Apparent loss, $a+b-(c+d+e)$.
1900.						
Experiment No. 26.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Feb. 14–15, 7 a. m. to 7 a. m..	1,046.3	800	57.0	1,157.3	829.1	−197.1
15–16, 7 a. m. to 7 a. m..	1,046.3	800	57.0	1,472.4	806.6	−489.7
16–17, 7 a. m. to 7 a. m..	1,046.3	800	57.0	1,289.0	799.5	−299.2
Total, 3 days	3,138.9	2,400	171.0	3,918.7	2,435.2	−986.0
Average, 1 day	1,046.3	800	57.0	1,306.2	811.7	−328.6
Experiment No. 28.						
Feb. 20–21, 7 a. m. to 7 a. m..	1,040.0	800	51.7	1,113.2	836.6	−161.5
21–22, 7 a. m. to 7 a. m..	1,040.0	800	51.8	1,238.0	813.8	−263.6
22–23, 7 a. m. to 7 a. m..	1,040.0	800	51.7	1,150.3	790.6	−152.6
Total, 3 days	3,120.0	2,400	155.2	3,501.5	2,441.0	−577.7
Average, 1 day	1,040.0	800	51.7	1,167.2	813.7	−192.6

TABLE 108.—*Income and outgo of water and hydrogen—Metabolism experiments Nos. 26 and 28*—Continued.

Date.	Hydrogen.					
	(*g*) In food.	(*h*) In feces.	(*i*) In urine.	(*l*) Apparent gain, (*g*−(*h*+*i*).	(*m*) Loss from water, *f* +9.	(*n*) Total gain(+) or loss (−), *l*+*m*.
1900.						
Experiment No. 26.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Feb. 14–15, 7 a. m. to 7 a. m.	33.9	1.1	2.9	+29.9	− 21.9	+ 8.0
15–16, 7 a. m. to 7 a. m.	33.8	1.2	2.6	+30.0	− 54.4	−24.4
16–17, 7 a. m. to 7 a. m.	33.9	1.1	2.5	+30.3	− 33.2	− 2.9
Total, 3 days	101.6	3.4	8.0	+90.2	−109.5	−19.3
Average, 1 day	33.9	1.1	2.7	+30.1	− 36.5	− 6.4
Experiment No. 28.						
Feb. 20–21, 7 a. m. to 7 a. m.	35.8	1.3	2.8	+31.7	− 17.9	+13.8
21–22, 7 a. m. to 7 a. m.	35.8	1.4	2.6	+31.8	− 29.3	+ 2.5
22–23, 7 a. m. to 7 a. m.	35.8	1.3	2.5	+32.0	− 17.0	+15.0
Total, 3 days	107.4	4.0	7.9	+95.5	− 64.2	+31.3
Average, 1 day	35.8	1.3	2.7	+31.8	− 21.4	+10.4

TABLE 109.—*Gain or loss of protein (N×6.25), fat, and water—Metabolism experiments Nos. 26 and 28.*

Date.	(*a*) Nitrogen gained (+) or lost (−).	(*b*) Protein gained (+) or lost (−), *a*×6.25.	(*c*) Total carbon gained (+) or lost (−).	(*d*) Carbon in protein gained (+) or lost (−), *b*×0.53.	(*e*) Carbon in fat, etc., gained (+) or lost (−), *c*−*d*.	(*f*) Fat gained (+) or lost (−), *e*÷0.761.
1900.						
Experiment No. 26.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Feb. 14–15, 7 a. m. to 7 a. m.	−1.8	−11.2	+17.0	−5.9	+22.9	+30.1
15–16, 7 a. m. to 7 a. m.	− .3	− 1.9	+14.5	−1.0	+15.5	+20.4
16–17, 7 a. m. to 7 a. m.	+ .4	+ 2.5	+18.5	+1.3	+17.2	+22.6
Total, 3 days	−1.7	−10.6	+50.0	−5.6	+55.6	+73.1
Average, 1 day	− .6	− 3.5	+16.7	−1.8	+18.5	+24.4
Experiment No. 28.						
Feb. 20–21, 7 a. m. to 7 a. m.	−1.3	− 8.1	+13.4	−4.3	+17.7	+23.3
21–22, 7 a. m. to 7 a. m.	− .8	− 5.0	+12.1	−2.7	+14.8	+19.4
22–23, 7 a. m. to 7 a. m.	− .1	− .6	+17.0	− .3	+17.3	+22.7
Total, 3 days	−2.2	−13.7	+42.5	−7.3	+49.8	+65.4
Average, 1 day	− .7	− 4.5	+14.2	−2.4	+16.6	+21.8

TABLE 109.—*Gain or loss of protein (N×6.25), fat, and water—Metabolism experiments Nos. 26 and 28*—Continued.

Date.	(*g*) Total hydrogen gained (+) or lost (−).	(*h*) Hydrogen in protein gained (+) or lost (−), *b*×0.07.	(*i*) Hydrogen in fat gained (+) or lost (−), *f*×0.118.	(*k*) Hydrogen in water, etc., gained (+) or lost (−), *g*−(*h*+*i*).	(*l*) Water gained (+) or lost (−), *k*×9.
1900.					
Experiment No. 26.	*Grams*	*Gram.*	*Grams.*	*Grams.*	*Grams.*
Feb. 14–15, 7 a. m. to 7 a. m.	+ 8.0	−0.8	+3.6	+ 5.2	+ 46.8
15–16, 7 a. m. to 7 a. m.	−24.4	− .1	+2.4	−26.7	−240.3
16–17, 7 a. m. to 7 a. m.	− 2.9	+ .2	+2.7	− 5.8	− 52.2
Total, 3 days	−19.3	− .7	+8.7	−27.3	−245.7
Average, 1 day	− 6.4	− .2	+2.9	− 9.1	− 81.9
Experiment No. 28.					
Feb. 20–21, 7 a. m. to 7 a. m.	+13.8	− .6	+2.7	+11.7	+105.3
21–22, 7 a. m. to 7 a. m.	+ 2.5	− .3	+2.3	+ .5	+ 4.5
22–23, 7 a. m. to 7 a. m.	+15.0	.....	+2.7	+12.3	+110.7
Total, 3 days	+31.3	− .9	+7.7	+24.5	+220.5
Average, 1 day	+10.4	− .3	+2.5	+ 8.2	+ 73.5

TABLE 110.—*Income and outgo of energy—Metabolism experiments Nos. 26 and 28.*

Date.	(*a*) Heat of combustion of food eaten.	(*b*) Heat of combustion of feces.	(*c*) Heat of combustion of urine.	(*d*) Estimated heat of combustion of protein gained (+) or lost (−).	(*e*) Estimated heat of combustion of fat gained (+) or lost (−).	(*f*) Estimated energy of material oxidized in the body, *a*−(*b*+*c*+*d*−*e*).	(*g*) Heat determined.	(*h*) Heat determined greater (+) or less (−) than estimated, *g*−*f*.	(*i*) Heat determined greater (+) or less (−) than estimated, *h*÷*f*.
1900.									
Experiment No. 26.	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Per. ct.*
Feb. 14–15, 7 a. m. to 7 a. m.	2,490	106	125	−64	+287	2,036	2,077	+ 41	+2.0
15–16, 7 a. m. to 7 a. m.	2,490	106	125	−11	+195	2,075	2,100	+ 25	+1.2
16–17, 7 a. m. to 7 a. m.	2,490	106	135	+14	+216	2,019	2,078	+ 59	+2.9
Total, 3 days	7,470	318	385	−61	+698	6,130	6,255	+125	.....
Average, 1 day	2,490	106	128	−20	+233	2,043	2,085	+ 42	+2.0
Experiment No. 28.									
Feb. 20–21, 7 a. m. to 7 a. m.	2,489	112	119	−47	+222	2,083	2,097	+ 14	+ .7
21–22, 7 a. m. to 7 a. m.	2,489	112	133	−29	+185	2,088	2,075	− 13	− .6
22–23, 7 a. m. to 7 a. m.	2,489	112	132	− 3	+217	2,031	2,065	+ 34	+1.7
Total, 3 days	7,467	336	384	−79	+624	6,202	6,237	+ 35	.....
Average, 1 day	2,489	112	128	−26	+208	2,067	2,079	+ 12	+ .6

METABOLISM EXPERIMENTS NOS. 29 AND 31.

Subject.—J. F. S., the same person as in experiments Nos. 25, 26, and 28. His weight, with underclothing, was about 64.5 kilograms (142 pounds).

Occupation during experiment.—Worked 8 hours a day upon a stationary bicycle arranged as an ergometer, as described on page 20. The voltage of the electric current generated was measured, and the average number of pedal revolutions per minute observed. The current generated was passed through resistance within the chamber and thus transformed into heat, which was measured with the heat given off by the subject. The actual amount of work done each day was found by determining the watts required to drive the bicycle ergometer at the rate maintained by the subject during the experiment.

Duration.—Experiments Nos. 29 and 31 were the first and third of a series of 3, each of 3 days' duration. The intervening experiment is not reported here. The usual preliminary period continued 4 days, beginning with breakfast March 12, 1900. On the evening of the fourth day, March 15, the subject entered the calorimeter. Experiment No. 29 began at 7 a. m. March 16, and ended at 7 a. m. March 19. Experiment No. 31 began at 7 a. m. March 22, and ended at 7 a. m. March 25.

Diet.—The aim of this series of experiments was to study the relative replacing power of isodynamic quantities of different materials when the subject was at active exercise. There was, as usual, a basal ration supplemented by different materials. This basal ration was the same in both experiments, with the exception of slight differences due to variations in the composition of the milk consumed. It furnished approximately 100 grams of protein and 2,980 calories of energy per day. To this ration was added 128 grams of cane sugar per day, furnishing 507 calories of energy in experiment No. 29, and 63.5 grams of butter per day, furnishing 1 gram of protein and 511 calories of energy, in experiment No. 31. The kinds and quantities of food served at each meal and the quantities of drink at different periods of the day were as follows:

TABLE 111.—*Diet in metabolism experiments Nos. 29 and 31.*

FOOD—BASAL RATION.

Food materials.	Breakfast.	Dinner.	Supper.	Total.
	Grams.	*Grams.*	*Grams.*	*Grams.*
Beef	.....	58	.....	58
Butter	12	23	12	47
Milk, whole	300	300	300	900
Bread	75	150	75	300
Ginger snaps	25	25	25	75
Parched cereal	37.5	.....	37.5	75
Sugar	12.5	.....	12.5	25

FOOD—SUPPLEMENTAL RATION.

Experiment No. 29, March 16–18.—One hundred and twenty-eight grams of cane sugar daily in the form of loaf sugar, taken with and between meals. This amount also supplemented the basal ration during the preliminary experiment March 12–15.

Experiment No. 31, March 22–24.—The additional energy during this experiment was furnished by 63.5 grams butter.

DRINK.

Time.	Water.	Time.	Water.
	Grams.		*Grams.*
Breakfast	150	9.00 p. m	200
10.15 a. m	200	10.20 p. m	150
Dinner	200	Total for day	1,250
4.00 p. m	200		
Supper	150		

Daily routine.—The general plan of the series of experiments is indicated in the following schedule:

TABLE 112.—*Daily programme—Metabolism experiments Nos. 29 and 31.*

6.50 a. m	Take pulse and temperature.	4.00 p. m	Stop work, drink 200 grams water.
7.00 a. m	Pass urine, weigh self, collect drip, and weigh absorbers.	4.15 p. m	Begin work.
		6.15 p. m	Stop work, change underclothing.
7.30 a. m	Breakfast, drink 150 grams water.	6.20 p. m	Supper, drink 150 grams water.
8.15 a. m	Begin work.	6.50 p. m	Take pulse and temperature.
9.15 a. m	Stop work, drink 200 grams water.	7.00 p. m	Pass urine, weigh self, collect drip, and weigh absorbers.
10.30 a. m	Begin work.		
12.30 p. m	Stop work.	9.00 p. m	Drink 200 grams water.
12.50 p. m	Take pulse and temperature.	10.00 p. m	Take pulse and temperature.
1.00 p. m	Pass urine, collect drip, and weigh absorbers.	10.10 p. m	Arrange bed.
		10.20 p. m	Drink 150 grams water.
1.25 p. m	Dinner, drink 200 grams water.	10.30 p. m	Retire.
2.00 p. m	Begin work.	1.00 a. m	Pass urine.

Table 113 gives a condensed summary of the more important statistics in the diary kept by the subject.

TABLE 113.—*Summary of the diary—Metabolism experiments Nos. 29 and 31.*

Time.	Weight of subject in underclothes.	Pulse rate per minute.	Temperature.
1900.			
Preliminary observation.	*Kgs.*		°*F.*
Mar. 15, 9.40 a. m	.....	106	.....
11 a. m	.....	112	.....
12 m	.....	111	.....
12.55 p. m	.....	86	.....
12.58 p. m	.....	.....	97.8
7 p. m	64.51	.....	.....
8 p. m	.....	92	99.0
9 p. m	.....	87	98.4
Experiment No 29.			
Mar. 16, 7 a. m	63.85	71	97.6
9 a. m	.....	90	.....
10 a. m	.....	85	.....
11 a. m	.....	87	.....
12 m	.....	90	.....
1 p. m	.....	79	98.5
3 p. m	.....	101	.....
4 p. m	.....	108	.....
5 p. m	.....	102	.....
6 p. m	.....	88	.....
7 p. m	64.78	83	.....
9 p. m	.....	82	98.2
Mar. 17, 7 a. m	64.76	66	97.4
9 a. m	.....	92	.....
10 a. m	.....	96	.....
11 a. m	.....	94	.....
12 m	.....	94	.....
1 p. m	.....	74	98.4
3 p. m	.....	93	.....
4 p. m	.....	98	.....
5 p. m	.....	93	.....
6 p. m	.....	94	.....
7 p. m	65.12	77	97.9
8.08 p. m	.....	76	.....
8.12 p. m	.....	.....	97.6
9 p. m	.....	75	97.4
10 p. m	.....	69	.....
10.10 p. m	.....	.....	96.9
Mar. 18, 7 a. m	64.76	65	97.3
9 a. m	.....	88	.....
10 a. m	.....	93	.....
11 a. m	.....	91	.....
12 m	.....	92	.....
1 p. m	.....	69	98.0
3 p. m	.....	91	.....
4 p. m	.....	95	.....
5 p. m	.....	95	.....
6 p. m	.....	93	.....
7 p. m	64.96	79	97.8
8.15 p. m	.....	74	.....
8.23 p. m	.....	.....	97.4
9.15 p. m	.....	77	97.2
Mar. 18, 10.20 p. m	.....	66	.....
10.25 p. m	.....	.....	96.4
Experiment No. 31.			
Mar. 22, 6.55 a. m	64.09	65	.....
7 a. m	.....	.....	97.6
9 a. m	.....	93	.....
10 a. m	.....	87	.....
11 a. m	.....	90	.....
12 m	.....	87	.....
1 p. m	.....	67	97.8
3 p. m	.....	99	.....
4 p. m	.....	93	.....
5 p. m	.....	97	.....
6 p. m	.....	93	.....
6.55 p. m	.....	71	.....
7 p. m	64.55	.....	.....
8 p. m	.....	76	97.5
9 p. m	.....	70	97.0
10.12 p. m	.....	67	96.5
Mar. 23, 6.55 a. m	.....	68	97.6
7 a. m	64.24	.....	.....
9 a. m	.....	100	.....
10 a. m	.....	92	.....
11 a. m	.....	89	.....
12 m	.....	89	.....
3 p. m	.....	97	.....
4 p. m	.....	94	.....
5 p. m	.....	89	.....
6 p. m	.....	90	.....
7 p. m	64.68	74	97.6
8 p. m	.....	75	97.5
9 p. m	.....	68	.....
10.10 p. m	.....	66	.....
Mar. 24, 6.55 a. m	64.38	65	.....
9 a. m	.....	89	.....
10 a. m	.....	95	.....
11 a. m	.....	86	.....
12 m	.....	88	.....
12.55 p. m	.....	68	.....
1 p. m	.....	.....	97.8
3 p. m	.....	98	.....
4 p. m	.....	98	.....
5 p. m	.....	91	.....
6 p. m	.....	90	.....
7 p. m	64.90	76	97.4
8 p. m	.....	73	97.3
9 p. m	.....	71	.....
9.04 p. m	.....	.....	96.9
10.05 p. m	.....	66	.....
10.10 p. m	.....	.....	96.7
Mar. 25, 6.55 a. m	64.49	68	97.9

Amount of work done.—The total number of miles registered by the cyclometer on the different days of this series of experiments and the heat equivalent of the work done each day are shown in Table 114. It is altogether improbable that the amount of work done could have been as large as would be required to propel a bicycle, under ordinary conditions, the distance indicated by the cyclometer.

TABLE 114.—*Record of work done—Metabolism experiments Nos. 29 and 31.*

Date and time.	Cyclometer reading.	Number of miles.	(*a*) Actual duration of work.	(*b*) Rate.	(*c*) Heat equivalent, $a \times b \times 0.2378$.
1900.					
Experiment No. 29.			*Seconds.*	*Watts.*	*Calories.*
Mar. 16, 8.15 a. m.	666.0				
16, 10.15 a. m.	687.5	21.5	7,200	42.0	72
16, 12.30 p. m.	708.4	20.9	7,200	39.7	68
16, 4.00 p. m.	729.8	21.4	7,200	39.5	68
16, 6.15 p. m.	751.1	21.3	6,960	37.7	62
Total		85.1	28,560		270
Mar. 17, 10.15 a. m.	772.3	21.2	6,960	35.5	59
17, 12.30 p. m.	795.9	23.6	7,200	37.0	63
17, 4.00 p. m.	813.1	17.2	4,980	42.4	50
17, 6.15 p. m.	837.9	24.8	7,200	39.0	67
Total		86.8	26,340		239
Mar. 18, 10.15 a. m.	861.8	23.9	7,200	36.5	62
18, 12.30 p. m.	885.0	23.2	7,200	35.7	61
18, 4.00 p. m.	906.9	21.9	7,200	37.4	64
18, 6.15 p. m.	930.4	23.5	7,200	40.0	69
Total		92.5	28,800		256
Total, 3 days		264.4	83,700		765
Experiment No. 31.					
Mar. 22, 10.15 a. m.	1,194.4	21.2	7,200	37.4	64
22, 12.30 p. m.	1,218.0	23.6	7,200	38.7	66
22, 4.00 p. m.	1,240.9	22.9	7,200	39.0	67
22, 6.15 p. m.	1,262.9	22.0	7,200	37.0	63
Total		89.7	28,800		260
Mar. 23, 10.15 a. m.	1,289.7	26.8	7,200	37.2	64
23, 12.30 p. m.	1,306.8	17.1	7,200	37.0	63
23, 4.00 p. m.	1,329.9	23.1	7,200	37.4	64
23, 6.15 p. m.	1,351.4	21.5	7,200	34.4	59
Total		88.5	28,800		250
Mar. 24, 10.15 a. m.	1,375.8	24.4	7,200	37.0	63
24, 12.30 p. m.	1,400.7	24.9	7,200	35.7	61
24, 4.00 p. m.	1,423.7	23.0	6,240	35.7	53
24, 6.15 p. m.	1,447.4	23.7	7,200	34.9	60
Total		96.0	27,840		237
Total, 3 days		274.2	85,440		747

Detailed data of income and outgo.—The quantities of nutrients in the basal and supplemental rations during this series of experiments are shown in Table 115. The outgo of matter and energy in the feces during the successive experiments is shown in Table 116. Tables 117 and 118 show the amount and composition of the urine in experiments Nos. 29 and 31.

TABLE 115.—*Weight, composition, and heat of combustion of foods—Metabolism experiments Nos. 29 and 31.*

Laboratory No.	Food materials.	Weight per day.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
3186	Beef	58	35.0	20.7	1.7	.....	3.32	12.12	1.73	135
3187	Butter	47	4.3	.6	40.6	.....	.09	30.60	4.91	378
3192	Bread	300	109.5	28.2	6.0	152.4	4.50	87.42	12.90	879
3181	Ginger snaps	75	3.1	4.7	6.2	59.9	.75	33.24	4.96	333
3193	Parched cereal	75	3.1	9.0	1.1	60.4	1.44	32.04	4.72	315
	Sugar	25	.....	.....	.....	25.0	.....	10.52	1.62	99
	Basal ration, exclusive of milk	580	155.0	63.2	55.6	297.7	10.10	205.94	30.84	2,139
	EXPERIMENT NO. 29.									
3189	Milk, whole	900	760.5	36.9	50.4	45.0	5.94	73.80	11.34	841
	Total basal ration	1,480	915.5	100.1	106.0	342.7	16.04	279.74	42.18	2,980
	Loaf sugar (supplemental ration)	128	.....	.....	.....	128.0	.....	53.89	8.29	507
	Total ration, 1 day	**1,608**	**915.5**	**100.1**	**106.0**	**470.7**	**16.04**	**333.63**	**50.47**	**3,487**
	EXPERIMENT NO. 31.									
	Basal ration, exclusive of milk	580	155.0	63.2	55.6	297.7	10.10	205.94	30.84	2,139
3191	Milk, whole	900	760.5	36.9	50.4	45.0	5.85	74.25	11.34	845
	Total basal ration	1,480	915.5	100.1	106.0	342.7	15.95	280.19	42.18	2,984
3187	Butter (supplemental ration)	63.5	5.8	.8	54.8	.....	.13	41.34	6.63	511
	Total ration, 1 day	**1,543.5**	**921.3**	**100.9**	**160.8**	**342.7**	**16.08**	**321.53**	**48.81**	**3,495**

TABLE 116.—*Weight, composition, and heat of combustion of feces—Metabolism experiments Nos. 29 and 31.*

Laboratory No.		Weight of feces.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
	Experiment No. 29.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
3195	Total, 3 days	177.0	123.7	15.9	9.0	18.2	2.55	25.01	3.6	279
	Average, 1 day	59.0	41.2	5.3	3.0	6.1	.85	8.34	1.2	93
	Experiment No. 31.									
3197	Total, 3 days	160.1	108.1	15.2	8.2	18.1	2.43	24.32	3.4	272
	Average, 1 day	53.4	36.0	5.1	2.7	6.0	.81	8.11	1.1	91

TABLE 117.—*Amount, specific gravity, and nitrogen of urine, by 6-hour periods—Metabolism experiments Nos. 29 and 31.*

Date.	Period.	Amount of urine.	Specific gravity.	Nitrogen content.	
1900.	*Experiment No. 29.*	*Grams.*		*Per cent.*	*Grams.*
Mar. 16–17	7 a. m. to 1 p. m	169.5	1.032	2.14	3.63
	1 p. m. to 7 p. m	215.7	1.032	1.99	4.29
	7 p. m. to 1 a. m	171.2	1.035	2.39	4.09
	1 a. m. to 7 a. m	138.5	1.034	2.33	3.23
	Total	694.9			15.24
	Total by composite	694.9	1.034	2.21	15.36
17–18	7 a. m. to 1 p. m	189.2	1.031	2.05	3.88
	1 p. m. to 7 p. m	252.6	1.031	1.83	4.62
	7 p. m. to 1 a. m	183.6	1.033	2.26	4.15
	1 a. m. to 7 a. m	151.8	1.032	2.28	3.46
	Total	777.2			16.11
	Total by composite	777.2	1.031	2.06	16.01
18–19	7 a. m. to 1 p. m	227.5	1.029	1.75	3.98
	1 p. m. to 7 p. m	342.0	1.029	1.44	4.92
	7 p. m. to 1 a. m	182.1	1.032	2.15	3.91
	1 a. m. to 7 a. m	139.2	1.032	2.27	3.16
	Total	890.8			15.97
	Total by composite	890.8	1.030	1.80	16.03
	Total 3 days, by periods	2,362.9			47.32
	Total by composite	2,362.9			47.40
	Experiment No. 31.				
Mar. 22–23	7 a. m. to 1 p. m	252.3	1.027	1.62	4.09
	1 p. m. to 7 p. m	247.3	1.030	1.83	4.53
	7 p. m. to 1 a. m	172.3	1.033	2.39	4.12
	1 a. m. to 7 a. m	140.4	1.031	2.36	3.31
	Total	812.3			16.05
	Total by composite	812.3	1.030	1.99	16.16
23–24	7 a. m. to 1 p. m	213.2	1.029	1.84	3.92
	1 p. m. to 7 p. m	267.0	1.028	1.62	4.33
	7 p. m. to 1 a. m	173.3	1.031	2.22	3.85
	1 a. m. to 7 a. m	137.0	1.032	2.29	3.14
	Total	790.5			15.24
	Total by composite	790.5	1.030	1.91	15.10
24–25	7 a. m. to 1 p. m	240.3	1.028	1.55	3.72
	1 p. m. to 7 p. m	293.5	1.028	1.40	4.11
	7 p. m. to 1 a. m	188.0	1.033	2.04	3.84
	1 a. m. to 7 a. m	158.2	1.032	2.12	3.35
	Total	880.0			15.02
	Total by composite	880.0	1.030	[a]1.72	15.14
	Total 3 days, by periods	2,482.8			46.31
	Total by composite	2,482.8			46.40
	Total 9 days by composite[a]	8,006.2		1.78	142.50

[a] Including 3 days of an experiment not here reported.

TABLE 118.—*Daily elimination of carbon, hydrogen, water, and energy in urine—Metabolism experiments Nos. 29 and 31.*

Date.	Period.	Amount of urine.	Carbon.		Hydrogen.		Water.		Heat of combustion.	
									Per gram.	Total.
1900.	*Experiment No. 29.*	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*Calorie.*	*Calories.*
Mar. 16–17	7 a. m. to 7 a. m.....	694.9	.....	10.78	.....	2.86	.....	641.0	0.193	134
17–18	7 a. m. to 7 a. m.....	777.2	.....	11.39	.....	3.03	.....	720.3	.173	134
18–19	7 a. m. to 7 a. m.....	890.8	.....	11.29	.....	3.00	.....	834.3	.150	134
	Total.....	2,362.9	.....	33.46	.....	8.89	.....	2,195.6	.....	402
	Experiment No. 31.									
22–23	7 a. m. to 7 a. m.....	812.3	.....	11.35	.....	3.01	.....	755.6	.162	132
23–24	7 a. m. to 7 a. m.....	790.5	.....	10.78	.....	2.86	.....	736.6	.163	129
24–25	7 a. m. to 7 a. m.....	880.0	.....	10.62	.....	2.82	.....	826.9	.145	128
	Total.....	2,482.8	.....	32.75	.....	8.69	.....	2,319.1	.....	389
	Total, 9 days[a].	8,006.2	1.28	102.49	0.34	27.22	93.6	7,493.8	.....	1,211

[a] Including 3 days of an experiment not here reported.

The quantities of carbon dioxid and water in the ventilating air current are given in detail for experiments Nos. 29 and 31, in Tables 119–121, which follow. Table 122 shows the amount of heat given off during the successive 6-hour periods of the two experiments.

TABLE 119.—*Comparison of residual amounts of carbon dioxid and water in the chamber at the beginning and end of each period, and the corresponding gain or loss—Metabolism experiments Nos. 29 and 31.*

Date.	End of period.	Carbon dioxid.		Water.				
		Total amount in chamber.	Gain (+) or loss (−) over preceding period.	Total amount of vapor remaining in chamber.	Gain (+) or loss (−) over preceding period.	Change in weight of absorbers, gain (+) or loss (−).	Drip from absorbers.[a]	Total amount gained (+) or lost (−) during the period.
1900.	*Experiment No. 29.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 16	7 a. m	25.5	.....	46.7	.....	.....	.....	.....
16	1 p. m	75.1	+49.6	53.8	+ 7.1	+ 98	130.0	+235.1
16	7 p. m	79.0	+ 3.9	53.0	− .8	+194	236.0	+429.2
17	1 a. m	30.4	−48.6	50.2	− 2.8	− 69	22.7	− 49.1
17	7 a. m	25.7	− 4.7	47.1	− 3.1	− 69	12.0	− 60.1
	Total	.....	+ .2	.....	+ .4	+154	400.7	+555.1
17	1 p. m	85.3	+59.6	53.6	+ 6.5	+ 18	180.0	+204.5
17	7 p. m	77.1	− 8.2	52.4	− 1.2	+ 17	281.9	+297.7
18	1 a. m	26.4	−50.7	48.3	− 4.1	− 93	31.9	− 65.2
18	7 a. m	23.8	− 2.6	44.7	− 3.6	− 94	19.2	− 78.4
	Total	.....	− 1.9	.....	− 2.4	−152	513.0	+358.6
18	1 p. m	83.2	+59.4	51.7	+ 7.0	+169	120.0	+296.0
18	7 p. m	81.9	− 1.3	54.5	+ 2.8	+ 83	370.2	+456.0
19	1 a. m	28.5	−53.4	50.7	− 3.8	−110	54.2	− 59.6
19	7 a. m	26.8	− 1.7	48.1	− 2.6	−110	40.0	− 72.6
	Total	.....	+ 3.0	.....	+ 3.4	+ 32	584.4	+619.8
	Experiment No. 31.							
Mar. 22	7 a. m	26.4	.....	.....	.....	.....	.....	.....
22	1 p. m	78.9	+52.5	55.3	+10.1	+198	150.0	+358.1
22	7 p. m	75.2	− 3.7	52.4	− 2.9	− 17	369.2	+349.3
23	1 a. m	26.2	−49.0	48.1	− 4.3	− 88	29.6	− 62.7
23	7 a. m	25.7	− .5	45.2	− 2.9	− 88	20.0	− 70.9
	Total	.....	− .7	.....	.....	+ 5	568.8	+573.8
23	1 p. m	75.6	+49.9	54.6	+ 9.4	+180	120.0	+309.4
23	7 p. m	76.8	+ 1.2	52.8	− 1.8	− 15	357.7	+340.9
24	1 a. m	25.1	−51.7	50.2	− 2.6	− 83	26.4	− 59.2
24	7 a. m	24.7	− .4	45.2	− 5.0	− 83	18.0	− 70.0
	Total	.....	− 1.0	.....	.....	− 1	522.1	+521.1
24	1 p. m	78.1	+53.4	54.9	+ 9.7	+173	135.0	+317.7
24	7 p. m	70.3	− 7.8	52.4	− 2.5	− 5	364.4	+356.9
25	1 a. m	25.5	−44.8	48.3	− 4.1	− 76	28.9	− 51.2
25	7 a. m	27.6	+ 2.1	47.9	− .4	− 76	19.0	− 57.4
	Total	.....	+ 2.9	.....	+ 2.7	+ 16	547.3	+566.0

[a] The drip was collected and weighed but once a day. The volume was roughly observed at 1 p. m., 7 p. m., and 7 a. m., and this volume taken as a rough indication of the actual weight of drip for the different periods. The small amount of drip observed at 7 a. m. was divided equally between the two night periods. The figures in this column also include the perspiration in clothes, which amounted to 21, 23.8, 20.4, 18.3, 15.3, and 18.8 grams on the successive days of the series. The amount for each day has been divided equally between the periods ending at 1 p. m. and 7 p. m.

TABLE 120.—*Record of carbon dioxid in ventilating air current—Metabolism experiments Nos. 29 and 31.*

Date.	Period.	(a)	Carbon dioxid.						(h)
		Ventilation (number of liters of air).	In incoming air.		(d) In outgoing air.	(e) Total excess in outgoing air, $d-c$.	(f) Correction for amount remaining in chamber.	(g) Corrected amount exhaled by subject, $e+f$.	Total weight of carbon exhaled, $g \times \frac{3}{11}$.
			(b) Per liter.	(c) Total, $a \times b$.					
1900.	*Experiment No. 29.*	*Liters.*	*Mg.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 16–17	7 a. m. to 1 p. m..	27,208	0.598	16.3	406.2	389.9	+49.6	+439.5	119.9
	1 p. m. to 7 p. m..	27,985	.575	16.1	471.3	455.2	+ 3.9	459.1	125.2
	7 p. m. to 1 a. m..	27,985	.597	16.7	282.3	265.6	−48.6	217.0	59.2
	1 a. m. to 7 a. m..	27,208	.592	16.1	146.9	130.8	− 4.7	126.1	34.4
	Total.....	110,386	.....	65.2	1,306.7	1,241.5	+ .2	1,241.7	338.7
17–18	7 a. m. to 1 p. m..	25,653	.592	15.2	396.5	381.3	+59.6	440.9	120.2
	1 p. m. to 7 p. m..	27,208	.591	16.1	450.6	434.5	− 8.2	426.3	116.3
	7 p. m. to 1 a. m..	28,762	.595	17.1	258.3	241.2	−50.7	190.5	52.0
	1 a. m. to 7 a. m..	28,762	.594	17.1	147.3	130.2	− 2.6	127.6	34.8
	Total.....	110,385	.....	65.5	1,252.7	1,187.2	− 1.9	1,185.3	323.3
18–19	7 a. m. to 1 p. m..	27,208	.564	15.4	415.1	399.7	+59.4	459.1	125.2
	1 p. m. to 7 p. m..	27,208	.514	14.0	492.8	478.8	− 1.3	477.5	130.2
	7 p. m. to 1 a. m..	27,985	.601	16.8	262.1	245.3	−53.4	191.9	52.3
	1 a. m. to 7 a. m..	26,430	.576	15.2	145.2	130.0	− 1.7	128.3	35.0
	Total.....	108,831	.....	61.4	1,315.2	1,253.8	+ 3.0	1,256.8	342.7
	Total, 3 days	329,602	.....	192.1	3,874.6	3,682.5	+ 1.3	3,683.8	1,004.7
	Experiment No. 31.								
Mar. 22–23	7 a. m. to 1 p. m..	25,652	.578	14.8	387.5	372.7	+52.5	425.2	116.0
	1 p. m. to 7 p. m..	26,430	.600	15.8	447.7	431.9	− 3.7	428.2	116.8
	7 p. m. to 1 a. m..	27,985	.580	16.2	232.0	215.8	−49.0	166.8	45.5
	1 a. m. to 7 a. m..	26,430	.563	14.9	143.0	128.1	− .5	127.6	34.8
	Total.....	106,497	.....	61.7	1,210.2	1,148.5	− .7	1,147.8	313.1
23–24	7 a. m. to 1 p. m..	25,652	.578	14.8	381.7	366.9	+49.9	416.8	113.7
	1 p. m. to 7 p. m..	25,652	589	15.1	443.4	428.3	+ 1.2	429.5	117.1
	7 p. m. to 1 a. m..	27,985	.567	15.9	243.3	227.4	−51.7	175.7	47.9
	1 a. m. to 7 a. m..	28,762	.555	16.0	155.2	139.2	− .4	138.8	37.9
	Total.....	108,051	.....	61.8	1,223.6	1,161.8	− 1.0	1,160.8	316.6
24–25	7 a. m. to 1 p. m..	25,652	.568	14.6	378.5	363.9	+53.4	417.3	113.8
	1 p. m. to 7 p. m..	27,208	.581	15.8	455.4	439.6	− 7.8	431.8	117.8
	7 p. m. to 1 a. m..	27,985	.574	16.1	235.0	218.9	−44.8	174.1	47.5
	1 a. m. to 7 a. m..	27,985	.564	15.8	155.6	139.8	+ 2.1	141.9	38.7
	Total.....	108,830	.....	62.3	1,224.5	1,162.2	+ 2.9	1,165.1	317.8
	Total, 3 days	323,378	.....	185.8	3,658.3	3,472.5	+ 1.2	3,473.7	947.5

TABLE 121.—*Record of water in ventilating air current—Metabolism experiments Nos. 29 and 31.*

Date.	Period.	(a) Ventilation (number of liters of air).	Water in incoming air. (b) Per liter.	(c) Total, $a \times b$.	Water in outgoing air. (d) Amount condensed in freezers.	(e) Amount not condensed in freezers.	(f) Total, $d+e$.	(g) Total excess water in outgoing air, $f-c$.	(h) Correction for water remaining in chamber.	(i) Total water of respiration and perspiration, $g+h$.
1900.	*Experiment No. 29.*	*Liters.*	*Mg.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 16–17	7 a. m. to 1 p. m..	27,208	0.850	23.1	250.5	46.1	296.6	273.5	+235.1	508.6
	1 p. m. to 7 p. m..	27,985	.823	23.0	268.0	44.7	312.7	289.7	+429.2	718.9
	7 p. m. to 1 a. m..	27,985	.825	23.1	257.5	45.1	302.6	279.5	− 49.1	230.4
	1 a. m. to 7 a. m..	27,208	.756	20.6	249.5	40.8	290.3	269.7	− 60.1	209.6
	Total.....	110,386	.....	89.8	1,025.5	176.7	1,202.2	1,112.4	+555.1	1,667.5
17–18	7 a. m. to 1 p. m..	25,653	.832	21.4	233.1	42.6	275.7	254.3	+204.5	458.8
	1 p. m. to 7 p. m..	27,208	.849	23.1	268.8	43.6	312.4	289.3	+297.7	587.0
	7 p. m. to 1 a. m..	28,762	.840	24.2	247.2	49.5	296.7	272.5	− 65.2	207.3
	1 a. m. to 7 a. m..	28,762	.780	22.4	243.4	43.7	287.1	264.7	− 78.4	186.3
	Total.....	110,385	.....	91.1	992.5	179.4	1,171.9	1,080.8	+358.6	1,439.4
18–19	7 a. m. to 1 p. m..	27,208	.826	22.5	243.0	46.6	289.6	267.1	+296.0	563.1
	1 p. m. to 7 p. m..	27,208	.847	23.0	282.0	42.9	324.9	301.9	+456.0	757.9
	7 p. m. to 1 a. m..	27,985	.875	24.5	265.0	47.8	312.8	288.3	− 59.6	228.7
	1 a. m. to 7 a. m..	26,430	.861	22.8	243.9	38.3	282.2	259.4	− 72.6	186.8
	Total.....	108,831	.....	92.8	1,033.9	175.6	1,209.5	1,116.7	+619.8	1,736.5
	Total, 3 days	329,602	.....	273.7	3,051.9	531.7	3,583.6	3,309.9	+1,533.5	4,843.4
	Experiment No. 31.									
Mar. 22–23	7 a. m. to 1 p. m..	25,652	.828	21.2	247.7	40.4	288.1	266.9	+358.1	625.0
	1 p. m. to 7 p. m..	26,430	.857	22.6	259.4	39.8	299.2	276.6	+349.3	625.9
	7 p. m. to 1 a. m..	27,985	.816	22.8	246.3	41.2	287.5	264.7	− 62.7	202.0
	1 a. m. to 7 a. m..	26,430	.779	20.6	241.0	35.0	276.0	255.4	− 70.9	184.5
	Total.....	106,497	.....	87.2	994.4	156.4	1,150.8	1,063.6	+573.8	1,637.4
23–24	7 a. m. to 1 p. m..	25,652	.865	22.2	240.5	40.8	281.3	259.1	+309.4	568.5
	1 p. m. to 7 p. m..	25,652	.881	22.6	253.3	37.8	291.1	268.5	+340.9	609.4
	7 p. m. to 1 a. m..	27,985	.826	23.1	252.0	43.2	295.2	272.1	− 59.2	212.9
	1 a. m. to 7 a. m..	28,762	.780	22.4	253.2	38.5	291.7	269.3	− 70.0	199.3
	Total.....	108,051	.....	90.3	999.0	160.3	1,159.3	1,069.0	+521.1	1,590.1
24–25	7 a. m. to 1 p. m..	25,652	.843	21.6	241.7	40.7	282.4	260.8	+317.7	578.5
	1 p. m. to 7 p. m..	27,208	.851	23.2	269.8	40.3	310.1	286.9	+356.9	643.8
	7 p. m. to 1 a. m..	27,985	.802	22.4	247.5	43.5	291.0	268.6	− 51.2	217.4
	1 a. m. to 7 a. m..	27,985	.768	21.5	256.0	38.1	294.1	272.6	− 57.4	215.2
	Total.....	108,830	.....	88.7	1,015.0	162.6	1,177.6	1,088.9	+566.0	1,654.9
	Total, 3 days	323,378	.....	266.2	3,008.4	479.3	3,487.7	3,221.5	+1,660.9	4,882.4

TABLE 122.—*Summary of calorimetric measurements—Metabolism experiments Nos. 29 and 31.*

Date.	Period.	(a) Heat measured in terms of C_{20}.	(b) Change of temperature of calorimeter.	(c) Capacity correction of calorimeter, $b \times 60$.	(d) Correction due to temperature of food and dishes.*	(e) Water vaporized equals total amount exhaled less amount condensed in chamber.	(f) Heat used in vaporization of water, $e \times 0.592$.	(g) Total heat determined, $a+c+d+f$.
1900.	*Experiment No. 29.*	*Calories.*	*Degree.*	*Calories.*	*Calories.*	*Grams.*	*Calories.*	*Calories.*
Mar. 16–17	7 a. m. to 1 p. m...	1,113.0	+0.02	+ 1.2	+ 1.7	280.6	166.1	1,282.0
	1 p. m. to 7 p. m...	1,139.0	+ .09	+ 5.4	− 2.6	288.9	171.0	1,312.8
	7 p. m. to 1 a. m...	495.3	+ .01	+ .6	+ 6.3	276.7	163.8	666.0
	1 a. m. to 7 a. m...	250.1	+ .01	+ .6	.....	266.6	157.8	408.5
	Total.....	2,997.4	+ .13	+ 7.8	+ 5.4	1,112.8	658.7	3,669.3
17–18	7 a. m. to 1 p. m...	1,074.3	+ .01	+ .6	+ 2.8	260.8	154.4	1,232.1
	1 p. m. to 7 p. m...	1,078.3	+ .05	+ 3.0	− 4.7	288.1	170.6	1,247.2
	7 p. m. to 1 a. m...	414.1	0	0	+ 5.4	268.4	158.9	578.4
	1 a. m. to 7 a. m...	216.3	+ .03	+ 1.8	.....	261.1	154.5	372.6
	Total.....	2,783.0	+ .09	+ 5.4	+ 3.5	1,078.4	638.4	3,430.3
18–19	7 a. m. to 1 p. m...	1,116.2	+ .04	+ 2.4	+ 7.2	274.1	162.2	1,288.0
	1 p. m. to 7 p. m...	1,195.8	+ .11	+ 6.6	− 7.0	304.7	180.4	1,375.8
	7 p. m. to 1 a. m...	468.5	+ .02	+ 1.2	+ 5.8	284.5	168.4	643.9
	1 a. m. to 7 a. m...	208.0	+ .03	+ 1.8	.....	256.8	152.0	361.8
	Total.....	2,988.5	+ .20	+12.0	+ 6.0	1,120.1	663.0	3,669.5
	Total, 3 days	8,768.9	.....	+25.2	+14.9	3,311.3	1,960.1	10,769.1
	Experiment No. 31.							
Mar. 22–23	7 a. m. to 1 p. m...	1,082.2	− .01	− .6	+ 3.1	277.0	164.0	1,248.7
	1 p. m. to 7 p. m...	1,087.6	0	0	− 4.1	273.7	162.0	1,245.5
	7 p. m. to 7 a. m...	405.9	0	0	+ 3.1	260.4	154.1	563.1
	1 a. m. to 7 a. m...	221.9	+ .01	+ .6	.....	252.5	149.5	372.0
	Total.....	2,797.6	.....	.....	+ 2.1	1,063.6	629.6	3,429.3
23–24	7 a. m. to 1 p. m...	1,058.7	+ .01	+ .6	+ 1.5	268.5	159.0	1,219.8
	1 p. m. to 7 p. m...	1,103.8	+ .02	+ 1.2	− 5.6	266.7	157.9	1,257.3
	7 p. m. to 1 a. m...	394.1	0	0	+ .8	269.5	159.5	554.4
	1 a. m. to 7 a. m...	224.3	+ .01	+ .6	.....	264.3	156.4	381.3
	Total.....	2,780.9	+ .04	+ 2.4	− 3.3	1,069.0	632.8	3,412.8
24–25	7 a. m. to 1 p. m...	1,071.0	.....	.....	+ 1.1	270.5	160.1	1,232.2
	1 p. m. to 7 p. m...	1,094.6	+ .01	+ .6	+ 2.3	284.4	168.4	1,265.9
	7 p. m. to 1 a. m...	378.5	− .01	− .6	+ 4.9	264.5	156.6	539.4
	1 a. m. to 7 a. m...	218.1	+ .01	+ .6	.....	272.2	161.0	379.7
	Total.....	2,762.2	+ .01	+ .6	+ 8.3	1,091.6	646.1	3,417.2
	Total, 3 days	8,340.7	.....	+ 3.0	+ 7.1	3,224.2	1,908.5	10,259.3

*Including correction for 4.8 calories introduced during each day period by the current used to magnetize the fields of the dynamo.

Balance of income and outgo of matter and energy.—The income and outgo of nitrogen, carbon, hydrogen, and energy in experiments Nos. 29 and 31 are shown in Tables 123–126.

TABLE 123.—*Income and outgo of nitrogen and carbon—Metabolism experiments Nos. 29 and 31.*

Date.	Nitrogen.				Carbon.				
	(*a*) In food.	(*b*) In feces.	(*c*) In urine.[a]	(*d*) Gain (+) or loss (−), *a* −(*b*+*c*).	(*e*) In food.	(*f*) In feces.	(*g*) In urine.	(*h*) In respiratory products.	(*k*) Gain (+) or loss (−), *e* −(*f*+*g*+*h*).
1900.									
Experiment No. 29.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 16–17, 7 a. m. to 7 a. m.	16.0	0.9	15.4	−0.3	333.6	8.3	10.8	338.7	−24.2
17–18, 7 a. m. to 7 a. m.	16.1	.8	16.3	−1.0	333.7	8.4	11.4	323.3	− 9.4
18–19, 7 a. m. to 7 a. m.	16.0	.9	16.2	−1.1	333.6	8.3	11.3	342.7	−28.7
Total, 3 days	48.1	2.6	47.9	−2.4	1,000.9	25.0	33.5	1,004.7	−62.3
Average, 1 day	16.0	.8	16.0	− .8	333.6	8.3	11.2	334.9	−20.8
Experiment No. 31.									
Mar. 22–23, 7 a. m. to 7 a. m.	16.1	.8	16.3	−1.0	321.5	8.1	11.3	313.1	−11.0
23–24, 7 a. m. to 7 a. m.	16.0	.8	15.4	− .2	321.6	8.1	10.8	316.6	−13.9
24–25, 7 a. m. to 7 a. m.	16.1	.8	15.2	+ .1	321.5	8.1	10.6	317.8	−15.0
Total, 3 days	48.2	2.4	46.9	−1.1	964.6	24.3	32.7	947.5	−39.9
Average, 1 day	16.1	.8	15.6	− .3	321.5	8.1	10.9	315.8	− 13.3

[a] Including nitrogen in perspiration, amounting to 0.2 gram per day.

TABLE 124.—*Income and outgo of water and hydrogen—Metabolism experiments Nos. 29 and 31.*

Date.	Water.					
	(*a*) In food.	(*b*) In drink.	(*c*) In feces.	(*d*) In urine.	(*e*) In respiratory products.	(*f*) Apparent loss, *a*+*b*−(*c*+*d*+*e*).
1900.						
Experiment No. 29.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 16–17, 7 a. m. to 7 a. m.	915.5	1,250	41.2	641.0	1,667.5	184.2
17–18, 7 a. m. to 7 a. m.	915.5	1,250	41.3	720.3	1,439.4	35.5
18–19, 7 a. m. to 7 a. m.	915.5	1,250	41.2	834.3	1,736.5	446.5
Total, 3 days	2,746.5	3,750	123.7	2,195.6	4,843.4	666.2
Average, 1 day	915.5	1,250	41.2	731.9	1,614.5	222.1
Experiment No. 31.						
Mar. 22–23, 7 a. m. to 7 a. m.	921.3	1,250	36.0	755.6	1,637.4	257.7
23–24, 7 a. m. to 7 a. m.	921.3	1,250	36.1	736.6	1,590.1	191.5
24–25, 7 a. m. to 7 a. m.	921.3	1,250	36.0	826.9	1,654.9	346.5
Total, 3 days	2,763.9	3,750	108.1	2,319.1	4,882.4	795.7
Average, 1 day	921.3	1,250	36.0	773.0	1,627.5	265.2

TABLE 124.—*Income and outgo of water and hydrogen—Metabolism experiments Nos. 29 and 31*—Continued.

Date.	Hydrogen. (g) In food.	(h) In feces.	(i) In urine.	(l) Apparent gain, $g-(h+i)$.	(m) Loss from water $f \div 9$.	(n) Total gain (+) or loss (−) $l+m$.
1900.						
Experiment No. 29.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 16–17, 7 a. m. to 7 a. m.	50.5	1.2	2.9	+ 46.4	−20.5	+25.9
17–18, 7 a. m. to 7 a. m.	50.5	1.2	3.0	+ 46.3	− 3.9	+42.4
18–19, 7 a. m. to 7 a. m.	50.5	1.2	3.0	+ 46.3	−49.6	− 3.3
Total, 3 days	151.5	3.6	8.9	+139.0	−74.0	+65.0
Average, 1 day	50.5	1.2	3.0	+ 46.3	−24.6	+21.7
Experiment No. 31.						
Mar. 22–23, 7 a. m. to 7 a. m.	48.8	1.1	3.0	+ 44.7	−28.6	+16.1
23–24, 7 a. m. to 7 a. m.	48.8	1.2	2.9	+ 44.7	−21.3	+23.4
24–25, 7 a. m. to 7 a. m.	48.8	1.1	2.8	+ 44.9	− 38.5	+ 6.4
Total, 3 days	146.4	3.4	8.7	+134.3	−88.4	+45.9
Average, 1 day	48.8	1.1	2.9	+ 44.8	−29.5	+15.3

TABLE 125.—*Gain or loss of protein ($N \times 6.25$), fat, and water—Metabolism experiments Nos. 29 and 31.*

Date.	(a) Nitrogen gained (+) or lost (−).	(b) Protein gained (+) or lost (−), $a \times 6.25$.	(c) Total carbon gained (+) or lost (−).	(d) Carbon in protein gained (+) or lost (−), $b \times 0.53$.	(e) Carbon in fat, etc., gained (+) or lost (−), $c-d$.	(f) Fat gained (+) or lost (−), $e \div 0.761$.
1900.						
Experiment No. 29.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 16–17, 7 a. m. to 7 a. m.	−0.3	− 1.9	−24.2	−1.0	−23.2	−30.5
17–18, 7 a. m. to 7 a. m.	−1.0	− 6.2	− 9.4	−3.3	− 6.1	− 8.0
18–19, 7 a. m. to 7 a. m.	−1.1	− 6.9	−28.7	−3.7	−25.0	−32.9
Total, 3 days	−2.4	−15.0	−62.3	−8.0	−54.3	−71.4
Average, 1 day	− .8	− 5.0	−20.8	−2.7	−18.1	−23.8
Experiment No. 31.						
Mar. 22–23, 7 a. m. to 7 a. m.	−1.0	− 6.2	−11.0	−3.3	− 7.7	−10.1
23–24, 7 a. m. to 7 a. m.	− .2	− 1.3	−13.9	− .7	−13.2	−17.3
24–25, 7 a. m. to 7 a. m.	+ .1	+ .6	−15.0	+ .3	−15.3	−20.1
Total, 3 days	−1.1	− 6.9	−39.9	−3.7	−36.2	−47.5
Average, 1 day	− .3	− 2.3	−13.3	−1.2	−12.1	−15.9

TABLE 125.—*Gain or loss of protein (N×6.25), fat, and water—Metabolism experiments Nos. 29 and 31*—Continued.

Date.	(*g*) Total hydrogen gained (+) or lost (−).	(*h*) Hydrogen in protein gained (+) or lost (−), *b* ×0.07.	(*i*) Hydrogen in fat gained (+) or lost (−), *f*×0.118.	(*k*) Hydrogen in water, etc., gained (+) or lost (−), *g* − (*h*+*i*).	(*l*) Water gained (+) or lost (−), *k*×9.
1900.					
Experiment No. 29.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Mar. 16–17, 7 a. m. to 7 a. m	+25.9	−0.1	−3.6	+29.6	+266.4
17–18, 7 a. m. to 7 a. m	+42.4	− .4	− .9	+43.7	+393.3
18–19, 7 a. m. to 7 a. m	− 3.3	− .5	−3.9	+ 1.1	+ 9.9
Total, 3 days	+65.0	−1.0	−8.4	+74.4	+669.6
Average, 1 day	+21.7	− .3	−2.8	+24.8	+223.2
Experiment No. 31.					
Mar. 22–23, 7 a. m. to 7 a. m	+16.1	− .4	−1.2	+17.7	+159.3
23–24, 7 a. m. to 7 a. m	+23.4	− .1	− 2.0	+25.5	+229.5
24–25, 7 a. m. to 7 a. m	+ 6.4	.....	−2.4	+ 8.8	+ 79.2
Total, 3 days	+45.9	− .5	−5.6	+52.0	+468.0
Average, 1 day	+15.3	− .1	−1.9	+17.3	+156.0

TABLE 126.—*Income and outgo of energy—Metabolism experiments Nos. 29 and 31.*

Date.	(*a*) Heat of combustion of food eaten.	(*b*) Heat of combustion of feces.	(*c*) Heat of combustion of urine.	(*d*) Estimated heat of combustion of protein gained (+) or lost (−).	(*e*) Estimated heat of combustion of fat gained (+) or lost (−).	(*f*) Estimated energy of material oxidized in the body *a*−(*b*+*c*+*d*+*e*).	(*g*) Heat determined.	(*h*) Heat determined, greater (+) or less (−) than estimated, *g*−*f*.	(*i*) Heat determined, greater (+) or less (−) than estimated, *h*÷*f*.
1900.									
Experiment No. 29.	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Per ct.*
Mar. 16–17, 7 a. m. to 7 a. m	3,487	93	134	−11	−291	3,562	3,669	+107	+3.0
17–18, 7 a. m. to 7 a. m	3,487	93	134	−35	− 76	3,371	3,430	+ 59	+1.7
18–19, 7 a. m. to 7 a. m	3,487	93	134	−39	−314	3,613	3,669	+ 56	+1.5
Total, 3 days	10,461	279	402	−85	−681	10,546	10,768	+222	.....
Average, 1 day	3,487	93	134	−28	−227	3,515	3,589	+ 74	+2.1
Experiment No. 31.									
Mar. 22–23, 7 a. m. to 7 a. m	3,495	91	132	−35	− 96	3,403	3,429	+ 26	+ .8
23–24, 7 a. m. to 7 a. m	3,495	90	129	− 7	−165	3,448	3,413	− 35	−1.0
24–25, 7 a. m. to 7 a. m	3,495	91	128	+ 3	−192	3,465	3,417	− 48	−1.4
Total, 3 days	10,485	272	389	−39	−453	10,316	10,259	− 57	.....
Average, 1 day	3,495	91	129	−13	−151	3,439	3,420	− 19	− .6

METABOLISM EXPERIMENTS NOS. 32 AND 34.

Subject.—J. F. S., who was also the subject of several preceding experiments. His weight, with underclothing, was about 66.6 kilograms (145½ pounds).

Occupation during experiment.—Worked 8 hours a day upon a stationary bicycle, as in the previous series of experiments.

Duration.—These two experiments, each of which continued 3 days, form the first and third of a series of 3. The intermediate experiment, also of 3 days' duration, is not reported here. A preliminary period of 4 days preceded the series, beginning with breakfast April 16, 1900. The subject entered the respiration chamber on the evening of April 19, and experiment No. 32 began at 7 a. m. April 20 and ended at 7 a. m. April 23. Experiment No. 34 began at 7 a. m. April 26 and ended at 7 a. m. April 29.

Diet.—These experiments were intended to be as nearly as possible a repetition of experiments Nos. 29 and 31, with the exception that the order in which the supplemental materials were added to the basal ration was reversed. The basal ration was practically the same in both experiments, differing slightly owing to the difference in the composition of the milk. It furnished approximately 100 grams of protein and 2,980 calories of energy per day. To this basal ration 63.5 grams of butter per day, furnishing 1 gram of protein and 509 calories of energy, was added in experiment No. 32, and 128 grams of cane sugar, furnishing 507 calories of energy, was added daily in experiment No. 34. The total ration therefore in these experiments furnished approximately 100 grams of protein and 3,490 calories of energy per day. The kinds and quantities of food served for each meal and the quantities of drink at different periods of the day were as follows:

TABLE 127.—*Diet in metabolism experiments Nos. 32 and 34.*

FOOD—BASAL RATION.

Food materials.	Breakfast.	Dinner.	Supper.	Total.
	Grams.	*Grams.*	*Grams.*	*Grams.*
Beef	.....	58	.....	58
Butter	9	17	9	35
Bread	75	150	75	300
Ginger snaps	25	25	25	75
Parched cereal	37.5	.....	37.5	75
Sugar	17.5	.....	17.5	35
Milk, whole	340	340	340	1,020

FOOD—SUPPLEMENTAL RATION.

Experiment No. 32, April 20–22.—Sixty-two grams butter added to basal ration. This amount also supplemented the ration during the preliminary period.

Experiment No. 34, April 26–28.—The basal ration during this experiment was increased by the addition of 128 grams of cane sugar.

DRINK.

Time.	Water.	Time.	Water.
	Grams.		*Grams.*
Breakfast	150	Supper	150
10.15 a. m.	200	9.00 p. m.	200
Dinner	200	10.20 p. m.	150
4.00 p. m.	200	Total for day	1,250

Daily routine.—The general plan of the series of experiments was identical with that of the previous series, and is shown in the following schedule:

TABLE 128.—*Daily programme—Metabolism experiments Nos. 32 and 34.*

6.50 a. m	Take pulse and temperature.	4.00 p. m	Stop work; drink 200 grams water.
7.00 a. m	Pass urine, weigh self-dressed, collect drip, and weigh absorbers.	4.15 p. m	Begin work.
		6.15 p. m	Stop work; change underclothing.
7.30 a. m	Breakfast; drink 150 grams water.	6.20 p. m	Supper; drink 150 grams water.
		6.50 p. m	Take pulse and temperature.
8.15 a. m	Begin work.	7.00 p. m	Pass urine, weigh self-dressed, collect drip, and weigh absorbers.
10.15 a. m	Stop work; drink 200 grams water.		
12.30 p. m	Stop work.	9.00 p. m	Drink 200 grams water.
12.50 p. m	Take pulse and temperature.	10.00 p. m	Take pulse and temperature.
1.00 p. m	Pass urine, collect drip, and weigh absorbers.	10.10 p. m	Arrange bed.
		10.20 p. m	Drink 150 grams water.
1.25 p. m	Dinner; drink 200 grams water.	10.30 p. m	Retire.
2.00 p. m	Begin work.	1.00 a. m	Pass urine.

Table 129 gives a condensed summary of the diary kept by the subject during the experiment.

TABLE 129.—*Summary of the diary—Metabolism experiments Nos. 32 and 34.*

Time.	Weight of subject in underclothes.	Pulse rate per minute.	Temperature.	Time.	Weight of subject in underclothes.	Pulse rate per minute.	Temperature.
1900.				1900.			
Experiment No. 32.	*Kgs.*		° *F.*	*Experiment No. 34.*	*Kgs.*		° *F.*
Apr. 20, 7 a. m	66.19	66	97.8	Apr. 26, 7 a. m	64.94	68	97.7
10 a. m	.....	83	.....	10 a. m	.....	102	.....
1 p. m	.....	65	97.7	1 p. m	.....	66	97.7
4 p. m	.....	87	.....	4 p. m	.....	97	.....
7 p. m	66.95	72	97.8	7 p. m	65.44	77	97.7
10 p. m	.....	62	96.6	10 p. m	.....	69	97.2
Apr. 21, 7 a. m	66.36	64	97.8	Apr. 27, 7 a. m	65.09	65	97.6
10 a. m	.....	88	.....	10 a. m	.....	98	.....
1 p. m	.....	67	98.0	1 p. m	.....	71	98.3
4 p. m	.....	97	.....	4 p. m	.....	99	.....
7 p. m	66.27	74	97.9	7 p. m	65.34	73	97.7
10 p. m	.....	66	96.6	10 p. m	.....	68	97.3
Apr. 22, 7 a. m	65.83	68	97.7	Apr. 28, 7 a. m	64.98	67	97.9
10 a. m	.....	96	.....	10 a. m	.....	98	.....
1 p. m	.....	68	97.7	1 p. m	.....	66	97.8
4 p. m	.....	104	.....	4 p. m	.....	102	.....
7 p. m	65.59	79	97.7	7 p. m	65.37	73	97.0
10 p. m	.....	67	96.9	10 p. m	.....	69	97.3

Amount of work done.—The total number of miles registered by the cyclometer and the heat equivalent of the work done each day are shown in Table 130.

TABLE 130.—*Record of work done—Metabolism experiments Nos. 32 and 34.*

Time.	Cyclometer reading.	Number of miles.	(a) Actual duration of work.	(b) Rate.	(c) Heat equivalent, a×b×0.2378.
1900.					
Experiment No. 32.			*Seconds.*	*Watts.*	*Calories.*
Apr. 20, 8.15 a. m	1,510.4				
20, 10.15 a. m	1,527.2	16.8	7,200	18.8	32
20, 12.30 p. m	1,546.5	19.3	7,200	21.0	36
20, 4 p. m	1,562.8	16.3	7,200	16.7	29
20, 6.15 p. m	1,579.1	16.3	7,200	17.4	30
Total		68.7	28,800		127
Apr. 21, 10.15 a. m	1,599.2	20.1	7,200	21.0	36
21, 12.30 p. m	1,626.0	26.8	7,200	25.8	44
21, 4 p. m	1,654.0	28.0	7,200	30.5	52
21, 6.15 p. m	1,681.7	27.7	7,200	29.6	51
Total		102.6	28,800		183
Apr. 22, 10.15 a. m	1,711.6	29.9	7,200	36.2	62
22, 12.30 p. m	1,744.6	33.0	7,200	47.4	81
22, 4 p. m	1,774.5	29.9	7,200	38.1	65
22, 6.15 p. m	1,806.1	31.6	7,200	40.0	69
Total		124.4	28,800		277
Total, 3 days		295.7	86,400		587
Experiment No. 34.					
Apr. 26, 10.15 a. m	2,166.9	28.9	7,200	34.3	59
26, 12.30 p. m	2,196.7	29.8	7,200	35.4	60
26, 4 p. m	2,226.1	29.4	7,200	34.3	59
26, 6.15 p. m	2,254.1	28.0	7,200	33.7	58
Total		116.1	28,800		236
Apr. 27, 10.15 a. m	2,283.8	29.7	7,200	35.7	61
27, 12.30 p. m	2,318.7	34.9	7,200	36.8	63
27, 4 p. m	2,347.5	28.8	7,200	38.1	65
27, 6.15 p. m	2,379.0	31.5	7,200	38.7	66
Total		124.9	28,800		255
Apr. 28, 10.15 a. m	2,409.6	30.6	7,200	37.4	64
28, 12.30 p. m	2,441.5	31.9	7,200	38.1	65
28, 4 p. m	2,472.6	31.1	7,200	38.1	65
28, 6.15 p. m	2,503.8	31.2	7,200	38.1	65
Total		124.8	28,800		259
Total, 3 days		365.8	86,400		750

Detailed data of income and outgo.—The quantities of nutrients in the basal ration and the quantities in the supplemental rations for the two experiments are shown in Table 131 and the outgo of matter and energy in the feces in Table 132.

TABLE 131.—*Weight, composition, and heat of combustion of foods—Metabolism experiments Nos. 32 and 34.*

Laboratory No.	Food materials.	Weight per day.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
3205	Beef	58	37.4	18.6	1.6	.....	2.98	10.76	1.54	120
3206	Butter	35	2.9	.4	30.7	.....	.07	22.95	3.63	287
3204	Bread	300	113.4	25.8	7.5	149.4	4.14	84.81	12.90	861
3207	Ginger snaps	75	2.8	4.1	5.4	61.2	.66	32.90	5.40	333
3193	Parched cereal	75	3.1	9.0	1.1	60.4	1.44	32.04	4.73	315
.....	Sugar	35	.....	.....	.....	35.0	.....	14.74	2.27	139
	Basal ration, exclusive of milk	578	159.6	57.9	46.3	306.0	9.29	198.20	30.47	2,055
	EXPERIMENT NO. 32.									
3200	Milk, whole	1,020	871.1	41.8	51.0	47.9	6.73	81.09	12.14	923
	Total basal ration	1,598	1,030.7	99.7	97.3	353.9	16.02	279.29	42.61	2,978
3206	Butter (supplemental ration)	62	5.2	.8	54.3	.....	.12	40.66	6.43	509
	Total ration, 1 day	**1,660**	**1,035.9**	**100.5**	**151.6**	**353.9**	**16.14**	**319.95**	**49.04**	**3,487**
	EXPERIMENT NO. 34.									
	Basal ration, exclusive of milk	578	159.6	57.9	46.3	306.0	9.29	198.20	30.47	2,055
3202	Milk, whole	1,020	869.0	41.8	53.0	43.9	6.73	83.64	12.34	931
	Total basal ration	1,598	1,028.6	99.7	99.3	349.9	16.02	281.84	42.81	2,986
.....	Sugar (supplemental ration)	128	.....	.....	.....	128.0	.....	53.89	8.29	507
	Total ration, 1 day	**1,726**	**1,028.6**	**99.7**	**99.3**	**477.9**	**16.02**	**335.73**	**51.10**	**3,493**

TABLE 132.—*Weight, composition, and heat of combustion of feces—Metabolism experiments Nos. 32 and 34.*

Laboratory number.		Weight of feces.	Water.	Protein.	Fat.	Carbohydrates.	Nitrogen.	Carbon.	Hydrogen.	Heat of combustion.
	Experiment No. 32.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Calories.*
3209	Total, 3 days	293.3	214.7	22.3	13.2	28.2	3.55	37.75	5.46	425
	Average, 1 day	97.8	71.6	7.4	4.4	9.4	1.18	12.58	1.82	142
	Experiment No. 34.									
3211	Total, 3 days	255.9	179.9	22.0	14.8	23.3	3.53	34.70	4.94	377
	Average, 1 day	85.3	60.0	7.3	4.9	7.8	1.18	11.57	1.65	126

The statistics of the quantity and composition of the urine eliminated on different days and different periods of the day are shown in Tables 133 and 134. The statistics of measurements of carbon dioxid and water in the ventilating air current for 6-hour periods are given in Tables 135–137.

TABLE 133.—*Amount, specific gravity, and nitrogen of urine by 6-hour periods—Metabolism experiments Nos. 32 and 34.*

Date.	Period.	Amount of urine.	Specific gravity.	Nitrogen content.	
1900.	*Experiment No. 32.*	*Grams.*		*Per cent.*	*Grams.*
Apr. 20–21	7 a. m. to 1 p. m	279.6	1.026	1.41	3.94
	1 p. m. to 7 p. m	371.1	1.022	1.26	4.68
	7 p. m. to 1 a. m	324.8	1.018	1.21	3.93
	1 a. m. to 7 a. m	262.1	1.018	1.28	3.35
	Total	1,237.6			15.90
	Total by composite	1,237.6	1.021	1.28	15.84
21–22	7 a. m. to 1 p. m	446.6	1.015	.85	3.80
	1 p. m. to 7 p. m	586.5	1.015	.74	4.34
	7 p. m. to 1 a. m	240.0	1.022	1.50	3.60
	1 a. m. to 7 a. m	214.8	1.021	1.49	3.20
	Total	1,487.9			14.94
	Total by composite	1,487.9	1.018	1.01	15.03
22–23	7 a. m. to 1 p. m	404.3	1.020	.94	3.80
	1 p. m. to 7 p. m	358.2	1.023	1.20	4.30
	7 p. m. to 1 a. m	192.5	1.030	2.02	3.89
	1 a. m. to 7 a. m	149.1	1.029	2.15	3.21
	Total	1,104.1			15.20
	Total by composite	1,104.1	1.024	1.39	15.35
	Total, 3 days, by periods	3,829.6			46.04
	Total by composite	3,829.6			46.22
	Experiment No. 34.				
Apr. 26–27	7 a. m. to 1 p. m	243.4	1.027	1.75	4.26
	1 p. m. to 7 p. m	271.2	1.029	1.83	4.96
	7 p. m. to 1 a. m	192.7	1.030	2.29	4.41
	1 a. m. to 7 a. m	144.1	1.029	2.35	3.39
	Total	851.4			17.02
	Total by composite	851.4	1.030	1.98	16.86
27–28	7 a. m. to 1 p. m	257.2	1.024	1.59	4.09
	1 p. m. to 7 p. m	301.6	1.027	1.55	4.67
	7 p. m. to 1 a. m	200.1	1.029	1.93	3.86
	1 a. m. to 7 a. m	150.1	1.028	2.16	3.24
	Total	909.0			15.86
	Total by composite	909.0	1.026	1.70	15.45
28–29	7 a. m. to 1 p. m	280.4	1.025	1.43	4.01
	1 p. m. to 7 p. m	356.3	1.024	1.28	4.56
	7 p. m. to 1 a. m	302.5	1.021	1.44	4.36
	1 a. m. to 7 a. m	156.2	1.027	1.99	3.11
	Total	1,095.4			16.04
	Total by composite	1,095.4	1.024	1.45	15.88
	Total, 3 days, by periods	2,855.8			48.92
	Total by composite	2,855.8			48.19
	Total, 9 days,[a] by composite	9,910.0	1.024	1.46	144.79

[a] Including 3 days of an experiment not here reported.

TABLE 134.—*Daily elimination of carbon, hydrogen, water, and energy in urine—Metabolism experiments Nos. 32 and 34.*

Date.	Period.	Amount of urine.	Carbon.		Hydrogen.		Water.		Heat of combustion.	
									Per gram.	Total.
1900.	*Experiment No. 32.*	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*P. ct.*	*Grams.*	*Calorie.*	*Calories.*
Apr. 20-21	7 a. m. to 7 a. m...	1,237.6	.....	11.35	.....	3.13	.....	1,179.7	0.104	129
21-22	7 a. m. to 7 a. m...	1,487.9	.....	10.67	.....	2.95	.....	1,433.4	.076	113
22-23	7 a. m. to 7 a. m...	1,104.1	.....	10.85	.....	3.00	.....	1,048.7	.105	116
	Total, 3 days.	3,829.6	.....	32.87	.....	9.08	.....	3,661.8	.....	358
	Experiment No. 34.									
Apr. 26-27	7 a. m. to 7 a. m...	851.4	.....	12.15	.....	3.36	.....	789.4	.154	131
27-28	7 a. m. to 7 a. m...	909.0	.....	11.32	.....	3.13	.....	851.2	.137	125
28-29	7 a. m. to 7 a. m...	1,095.4	.....	11.45	.....	3.16	.....	1,036.9	.112	123
	Total, 3 days.	2,855.8	.....	34.92	.....	9.65	.....	2,677.5	.....	379
	Total, 9 days[a].	9,910.0	1.05	104.06	0.29	28.74	94.64	9,378.8	.111	1,090

[a] Including 3 days of an experiment not here reported.

TABLE 135.—*Comparison of residual amounts of carbon dioxid and water in the chamber at the beginning and end of each period, and the corresponding gain or loss—Metabolism experiments Nos. 32 and 34.*

Date.	End of period.	Carbon dioxid.		Water.				
		Total amount in chamber.	Gain (+) or loss (−) over preceding period.	Total amount of vapor remaining in chamber.	Gain (+) or loss (−) over preceding period.	Change in weight of absorbers,* gain (+) or loss (−).	Drip from absorbers.	Total amount gained (+) or lost (−) during the period.
1900.	*Experiment No. 32.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Apr. 20	7 a. m.	27.0	.....	39.0	.....	.....	.....	.....
20–21	1 p. m.	70.7	+43.7	49.0	+10.0	+127	35.7	+ 172.7
	7 p. m.	64.6	− 6.1	48.6	− .4	+ 30	130.0	+ 159.6
	1 a. m.	27.6	−37.0	44.5	− 4.1	− 55	8.0	− 51.1
	7 a. m.	27.6	.....	43.1	− 1.4	− 55	8.0	− 48.4
	Total.	.....	+ .6	.....	+ 4.1	+ 47	181.7	+ 232.8
21–22	1 p. m.	83.4	+55.8	52.3	+ 9.2	+190	94.0	+ 293.2
	7 p. m.	86.6	+ 3.2	52.6	+ .3	+ 12	424.8	+ 437.1
	1 a. m.	27.2	−59.4	46.2	− 6.4	− 86	28.0	− 64.4
	7 a. m.	30.4	+ 3.2	49.4	+ 3.2	− 85	28.0	− 53.8
	Total.	.....	+ 2.8	.....	+ 6.3	+ 31	574.8	+ 612.1
22–23	1 p. m.	92.5	+62.1	58.1	+ 8.7	+192	334.8	+ 535.5
	7 p. m.	86.8	− 5.7	53.8	− 4.3	− 26	595.0	+ 564.7
	1 a. m.	28.5	−58.3	49.6	− 4.2	− 70	40.0	− 34.2
	7 a. m.	27.0	− 1.5	46.7	− 2.9	− 70	40.0	− 32.9
	Total.	.....	− 3.4	.....	− 2.7	+ 26	1,009.8	+1,033.1
	Experiment No. 34.							
Apr. 26	7 a. m.	26.0	.....	46.0	.....	.....	.....	.....
26–27	1 p. m.	81.3	+55.3	54.9	+ 8.9	+184	231.5	+ 424.4
	7 p. m.	78.3	− 3.0	53.4	− 1.5	− 19	433.2	+ 412.7
	1 a. m.	28.1	−50.2	47.9	− 5.5	− 72	11.0	− 66.5
	7 a. m.	26.2	− 1.9	46.2	− 1.7	− 71	11.0	− 61.7
	Total.	.....	+ .2	.....	+ .2	+ 22	686.7	+ 708.9
27–28	1 p. m.	82.1	+55.9	54.7	+ 8.5	+155	247.2	+ 410.7
	7 p. m.	74.5	− 7.6	53.0	− 1.7	− 6	461.8	+ 454.1
	1 a. m.	25.3	−49.2	44.5	− 8.5	− 84	18.0	− 74.5
	7 a. m.	25.8	+ .5	45.0	+ .5	− 84	18.0	− 65.5
	Total.	.....	− .4	.....	− 1.2	− 19	745.0	+ 724.8
28–29	1 p. m.	81.9	+56.1	53.6	+ 8.6	+177	215.6	+ 401.2
	7 p. m.	78.1	− 3.8	52.4	− 1.2	− 7	456.3	+ 448.1
	1 a. m.	26.0	−52.1	46.4	− 6.0	− 78	13.0	− 71.0
	7 a. m.	25.1	− .9	43.5	− 2.9	− 78	13.0	− 67.9
	Total.	.....	− .7	.....	− 1.5	+ 14	697.9	+ 710.4

*Absorbers were not weighed between 7 p. m. and 7 a. m. The change in the weight during this time is divided equally between the two periods.

TABLE 136.—*Record of carbon dioxid in ventilating air current—Metabolism experiments Nos. 32 and 34.*

Date.	Period.	(a) Ventilation (number of liters of air).	Carbon dioxid. In incoming air. (b) Per liter.	(c) Total, a×b.	(d) In outgoing air.	(e) Total excess in outgoing air, d−c.	(f) Correction for amount remaining in chamber.	(g) Corrected amount exhaled by subject, e+f.	(h) Total weight of carbon exhaled, g×.4.
1900.	*Experiment No. 32.*	*Liters.*	*Mg.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Apr. 20-21	7 a. m. to 1 p. m..	25,652	0.559	14.3	350.9	336.6	+43.7	380.3	103.7
	1 p. m. to 7 p. m..	26,430	.620	16.4	393.9	377.5	− 6.1	371.4	101.3
	7 p. m. to 1 a. m..	27,985	.608	17.0	243.9	226.9	−37.0	189.9	51.8
	1 a. m. to 7 a. m..	27,208	.675	18.4	157.1	138.7	.....	138.7	37.8
	Total	107,275	.....	66.1	1,145.8	1,079.7	+ .6	1,080.3	294.6
21-22	7 a. m. to 1 p. m..	25,952	.675	17.5	385.1	367.6	+55.8	423.4	115.4
	1 p. m. to 7 p. m..	25,952	.640	16.6	472.8	456.2	+ 3.2	459.4	125.3
	7 p. m. to 1 a. m..	26,430	.583	15.4	257.2	241.8	−59.4	182.4	49.7
	1 a. m. to 7 a. m..	27,208	.614	16.7	158.3	141.6	+ 3.2	144.8	39.5
	Total	105,542	.....	66.2	1,273.4	1,207.2	+ 2.8	1,210.0	329.9
22-23	7 a. m. to 1 p. m..	26,730	.590	15.8	439.9	424.1	+62.1	486.2	132.6
	1 p. m. to 7 p. m..	25,952	.599	15.5	499.6	484.1	− 5.7	478.4	130.4
	7 p. m. to 1 a. m..	26,430	.599	15.8	267.7	251.9	−58.3	193.6	52.8
	1 a. m. to 7 a. m..	27,208	.601	16.3	151.9	135.6	− 1.5	134.1	36.6
	Total	106,320	.....	63.4	1,359.1	1,295.7	− 3.4	1,292.3	352.4
	Total, 3 days	319,137	.....	195.7	3,778.3	3,582.6	0	3,582.6	976.9
	Experiment No. 34.								
Apr. 26-27	7 a. m. to 1 p. m..	26,730	.582	15.6	418.1	402.5	+55.3	457.8	124.8
	1 p. m. to 7 p. m..	27,508	.578	15.9	483.8	467.9	− 3.0	464.9	126.8
	7 p. m. to 1 a. m..	27,208	.575	15.6	252.4	236.8	−50.2	186.6	50.9
	1 a. m. to 7 a. m..	27,208	.620	16.9	150.7	133.8	− 1.9	131.9	36.0
	Total	108,654	.....	64.0	1,305.0	1,241.0	+ .2	1,241.2	338.5
27-28	7 a. m. to 1 p. m..	28,285	.568	16.1	440.0	423.9	+55.9	479.8	130.9
	1 p. m. to 7 p. m..	27,507	.582	16.0	499.0	483.0	− 7.6	475.4	129.7
	7 p. m. to 1 a. m..	29,540	.580	17.1	262.0	244.9	−49.2	195.7	53.3
	1 a. m. to 7 a. m..	28,762	.587	16.9	152.1	135.2	+ .5	135.7	37.0
	Total	114,094	.....	66.1	1,353.1	1,287.0	− .4	1,286.6	350.9
28-29	7 a. m. to 1 p. m..	27,985	.561	15.7	434.5	418.8	+56.1	474.9	129.5
	1 p. m. to 7 p. m..	27,985	.553	15.5	498.0	482.5	− 3.8	478.7	130.6
	7 p. m. to 1 a. m..	28,762	.593	17.1	256.7	239.6	−52.1	187.5	51.1
	1 a. m. to 7 a. m .	29,540	.632	18.7	150.5	131.8	− .9	130.9	35.7
	Total	114,272	.....	67.0	1,339.7	1,272.7	− .7	1,272.0	346.9
	Total, 3 days	337,020	.....	197.1	3,997.8	3,800.7	− .9	3,799.8	1,036.3

TABLE 137.—*Record of water in ventilating air current—Metabolism experiments Nos. 32 and 34.*

Date.	Period.	(a) Ventilation (number of liters of air).	Water in incoming air. (b) Per liter.	Water in incoming air. (c) Total, $a \times b$.	Water in outgoing air. (d) Amount condensed in freezers.	Water in outgoing air. (e) Amount not condensed in freezers.	Water in outgoing air. (f) Total, $d+e$.	(g) Total excess water in outgoing air, $f-c$.	(h) Correction for water remaining in chamber.	(i) Total water of respiration and perspiration, $g+h$.
1900.	*Experiment No. 32.*	*Liters.*	*Mgs.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Apr. 20-21	7 a. m. to 1 p. m..	25,652	0.999	25.6	207.8	45.6	253.4	227.8	+172.7	400.5
	1 p. m. to 7 p. m..	26,430	.972	25.7	225.6	43.3	268.9	243.2	+159.6	402.8
	7 p. m. to 1 a. m..	27,985	.936	26.2	229.6	44.6	274.2	248.0	− 51.1	196.9
	1 a. m. to 7 a. m..	27,208	.859	23.4	231.0	37.5	268.5	245.1	− 48.4	196.7
	Total.....	107,275	.....	100.9	894.0	171.0	1,065.0	964.1	+232.8	1,196.9
21-22	7 a. m. to 1 p. m..	25,952	1.041	27.0	222.4	46.7	269.1	242.1	+293.2	535.3
	1 p. m. to 7 p. m..	25,952	1.060	27.5	213.4	51.8	265.2	237.7	+437.1	674.8
	7 p. m. to 1 a. m..	26,430	.886	23.4	241.2	44.2	285.4	262.0	− 64.4	197.6
	1 a. m. to 7 a. m..	27,208	1.818	22.2	240.2	38.5	278.7	256.5	− 53.8	202.7
	Total.....	105,542	.....	100.1	917.2	181.2	1,098.4	998.3	+612.1	1,610.4
22-23	7 a. m. to 1 p. m..	26,730	1.085	29.0	252.0	48.5	300.5	271.5	+535.5	807.0
	1 p. m. to 7 p. m..	25,952	1.169	30.3	260.1	46.8	306.9	276.6	+564.7	841.3
	7 p. m. to 1 a. m..	26,430	1.022	27.0	241.7	42.0	283.7	256.7	− 34.2	222.5
	1 a. m. to 7 a. m..	27,208	.879	23.9	241.0	39.3	280.3	256.4	− 32.9	223.5
	Total.....	106,320	.....	110.2	994.8	176.6	1,171.4	1,061.2	+1,033.1	2,094.3
	Total, 3 days	319,137	.....	311.2	2,806.0	528.8	3,334.8	3,023.6	1,878.0	4,901.6
	Experiment No. 34.									
Apr. 26-27	7 a. m. to 1 p. m..	26,730	.910	24.3	248.2	44.4	292.6	268.3	+424.4	692.7
	1 p. m. to 7 p. m..	27,508	.973	26.8	261.6	46.0	307.6	280.8	+412.7	693.5
	7 p. m. to 1 a. m..	27,208	.859	23.4	239.3	40.6	279.9	256.5	− 66.5	190.0
	1 a. m. to 7 a. m..	27,208	.776	21.1	246.8	35.6	282.4	261.3	− 61.7	199.6
	Total.....	108,654	.....	95.6	995.9	166.6	1,162.5	1,066.9	+708.9	1,775.8
27-28	7 a. m. to 1 p. m..	28,285	.938	26.5	250.2	45.6	295.8	269.3	+410.7	680.0
	1 p. m. to 7 p. m..	27,507	1.004	27.6	271.4	42.5	313.9	286.3	+454.1	740.4
	7 p. m. to 1 a. m..	29,540	.827	24.4	254.0	46.1	300.1	275.7	− 74.5	201.2
	1 a. m. to 7 a. m..	28,762	.764	22.0	250.6	39.6	290.2	268.2	− 65.5	202.7
	Total.....	114,094	.....	100.5	1,026.2	173.8	1,200.0	1,099.5	+724.8	1,824.3
28-29	7 a. m. to 1 p. m..	27,985	.927	25.9	253.5	46.7	300.2	274.3	+401.2	675.5
	1 p. m. to 7 p. m..	27,985	1.031	28.8	269.0	46.3	315.3	286.5	+448.1	734.6
	7 p. m. to 1 a. m..	28,762	.904	26.0	246.0	45.9	291.9	265.9	− 71.0	194.9
	1 a. m. to 7 a. m..	29,540	.828	24.4	253.3	41.6	294.9	270.5	− 67.9	202.6
	Total.....	114,272	.....	105.1	1,021.8	180.5	1,202.3	1,097.2	+710.4	1,807.6
	Total, 3 days	337,020	.....	301.2	3,043.9	520.9	3,564.8	3,263.6	2,144.1	5,407.7

Table 138 shows the amount of heat given off during the successive 6-hour periods of the two experiments.

TABLE 138.—*Summary of calorimetric measurements—Metabolism experiments Nos. 32 and 34.*

Date.	Period.	(*a*) Heat measured in terms of C_{20}.	(*b*) Change of temperature of calorimeter.	(*c*) Capacity correction of calorimeter, $b \times 60$.	(*d*) Correction due to temperature of food and dishes[a].	(*e*) Water vaporized equals total amount exhaled less amount condensed in chamber.	(*f*) Heat used in vaporization of water, $e \times 0.592$.	(*g*) Total heat determined, $a+c+d+f$.
1900.	*Experiment No. 32.*	*Calories.*	*Degree.*	*Calories.*	*Calories.*	*Grams.*	*Calories.*	*Calories.*
Apr. 20-21	7 a. m. to 1 p. m...	979.0	+0.14	+ 8.4	− 1.3	237.8	140.8	1,126.9
	1 p. m. to 7 p. m...	968.3	+ .16	+ 9.6	− 8.7	242.8	143.7	1,112.9
	7 p. m. to 1 a. m...	444.4	.....	.....	+ 4.0	243.9	144.4	592.8
	1 a. m. to 7 a. m...	274.6	+ .02	+ 1.2	.....	243.7	144.3	420.1
	Total.....	2,666.3	+ .32	+19.2	− 6.0	968.2	573.2	3,252.7
21-22	7 a. m. to 1 p. m...	1,076.6	+ .04	+ 2.4	− .2	251.3	148.8	1,227.6
	1 p. m. to 7 p. m...	1,204.1	+ .02	+ 1.2	−10.6	238.0	140.9	1,335.6
	7 p. m. to 1 a. m...	427.0	.....	.....	+ 4.0	255.6	151.3	582.3
	1 a. m. to 7 a. m...	251.7	+ .01	+ .6	.....	259.7	153.7	406.0
	Total.....	2,959.4	+ .07	+ 4.2	− 6.8	1,004.6	594.7	3,551.5
22-23	7 a. m. to 1 p. m...	1,276.9	− .03	− 1.8	− 1.5	280.2	165.9	1,439.5
	1 p. m. to 7 p. m...	1,299.5	+ .03	+ 1.8	−14.7	272.3	161.2	1,447.8
	7 p. m. to 1 a. m...	455.0	.....	.....	+ 3.8	252.5	149.5	608.3
	1 a. m. to 7 a. m...	243.8	.....	.....	.....	253.5	150.1	393.9
	Total.....	3,275.2	.....	.....	−12.4	1,058.5	626.7	3,889.5
	Total, 3 days	8,900.9	.....	+23.4	−25.2	3,031.3	1,794.6	10,693.7
	Experiment No. 34.							
Apr. 26-27	7 a. m. to 1 p. m...	1,159.4	− .07	− 4.2	− .6	277.2	164.1	1,318.7
	1 p. m. to 7 p. m...	1,151.8	.....	.....	−10.9	279.3	165.3	1,306.2
	7 p. m. to 1 a. m...	408.0	.....	.....	+ 3.8	251.0	148.6	560.4
	1 a. m. to 7 a. m...	229.5	.....	.....	.....	259.6	153.7	383.2
	Total.....	2,948.7	− .07	− 4.2	− 7.7	1,067.1	631.7	3,568.5
27-28	7 a. m. to 1 p. m...	1,158.9	− .06	− 3.6	− 1.0	277.8	164.4	1,318.8
	1 p. m. to 7 p. m...	1,205.8	− .05	− 3.0	− 4.4	284.6	168.5	1,366.8
	7 p. m. to 1 a. m...	396.6	.....	.....	+ 4.7	267.2	158.2	559.5
	1 a. m. to 7 a. m...	228.6	.....	.....	.....	268.7	159.1	387.7
	Total.....	2,989.9	− .11	− 6.6	− .7	1,098.3	650.2	3,632.8
28-29	7 a. m. to 1 p. m...	1,158.2	− .01	− .6	+ .7	282.9	167.4	1,325.7
	1 p. m. to 7 p. m...	1,171.8	+ .01	+ .6	−12.1	285.3	168.9	1,329.2
	7 p. m. to 1 a. m...	392.0	− .01	− .6	.....	259.9	153.9	545.3
	1 a. m. to 7 a. m...	202.1	.....	.....	.....	267.6	158.4	360.5
	Total.....	2,924.1	− .01	− .6	−11.4	1,095.7	648.6	3,560.7
	Total, 3 days	8,862.7	.....	−11.4	−19.8	3,261.1	1,930.5	10,762.0

[a] Including correction for 4.8 calories introduced during each day period by the electric current used to magnetize the fields of the dynamo.

Balance of income and outgo of matter and energy.—From the preceding statistics the income and outgo of nitrogen, carbon, hydrogen, and energy on the different days of the two experiments are computed, and the results are shown in Tables 139–142.

TABLE 139.—*Income and outgo of nitrogen and carbon—Metabolism experiments Nos. 32 and 34.*

Date.	Nitrogen.				Carbon.				
	(*a*) In food.	(*b*) In feces.	(*c*) In urine.[a]	(*d*) Gain (+) or loss (−), *a*−(*b*+*c*).	(*e*) In food.	(*f*) In feces.	(*g*) In urine.	(*h*) In respiratory products.	(*k*) Gain (+) or loss(−), *e*−(*f*+*g*+*h*).
1900.									
Experiment No. 32.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Apr. 20–21, 7 a. m. to 7 a. m...	16.1	1.2	16.3	−1.4	320.0	12.6	11.3	294.6	+ 1.5
21–22, 7 a. m. to 7 a. m...	16.2	1.2	15.3	− .3	320.0	12.6	10.7	329.9	−33.2
22–23, 7 a. m. to 7 a. m...	16.1	1.2	15.6	− .7	320.0	12.6	10.9	352.4	−55.9
Total, 3 days.....	48.4	3.6	47.2	−2.4	960.0	37.8	32.9	976.9	−87.6
Average, 1 day	16.1	1.2	15.7	− .8	320.0	12.6	11.0	325.6	−29.2
Experiment No. 34.									
Apr. 26–27, 7 a. m. to 7 a. m...	16.0	1.2	17.4	−2.6	335.7	11.6	12.2	338.5	−26.6
27–28, 7 a. m. to 7 a. m...	16.0	1.2	16.3	−1.5	335.8	11.5	11.3	350.9	−37.9
28–29, 7 a. m. to 7 a. m...	16.0	1.2	16.4	−1.6	335.7	11.6	11.4	346.9	−34.2
Total, 3 days.....	48.0	3.6	50.1	−5.7	1,007.2	34.7	34.9	1,036.3	−98.7
Average, 1 day	16.0	1.2	16.7	−1.9	335.7	11.6	11.6	345.4	−32.9

[a] Including nitrogen in perspiration, amounting to 0.4 gram per day.

TABLE 140.—*Income and outgo of water and hydrogen—Metabolism experiments Nos. 32 and 34.*

Date.	Water.					
	(*a*) In food.	(*b*) In drink.	(*c*) In feces.	(*d*) In urine.	(*e*) In respiration products.	(*f*) Apparent loss, *a*+*b*−(*c*+*d*+*e*).
1900.						
Experiment No. 32.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Apr. 20–21, 7 a. m. to 7 a. m	1,035.9	1,250	71.6	1,179.7	1,196.9	162.3
21–22, 7 a. m. to 7 a. m	1,035.9	1,250	71.5	1,433.4	1,610.4	829.4
22–23, 7 a. m. to 7 a. m	1,035.9	1,250	71.6	1,048.7	2,094.3	928.7
Total, 3 days.....	3,107.7	3,750	214.7	3,661.8	4,901.6	1,920.4
Average, 1 day.....	1,035.9	1,250	71.6	1,220.6	1,633.8	640.1
Experiment No. 34.						
Apr. 26–27, 7 a. m. to 7 a. m	1,028.6	1,250	60.0	789.4	1,775.8	346.6
27–28, 7 a. m. to 7 a. m	1,028.6	1,250	59.9	851.2	1,824.3	456.8
28–29, 7 a. m. to 7 a. m	1,028.6	1,250	60.0	1,036.9	1,807.6	625.9
Total, 3 days.....	3,085.8	3,750	179.9	2,677.5	5,407.7	1,429.3
Average, 1 day.....	1,028.6	1,250	60.0	892.5	1,802.5	476.4

TABLE 140.—*Income and outgo of water and hydrogen—Metabolism experiments Nos. 32 and 34*—Continued.

Date.	Hydrogen.					
	(*g*) In food.	(*h*) In feces.	(*i*) In urine.	(*l*) Apparent gain, $g-(h+i)$.	(*m*) Loss from water, $f+9$.	(*n*) Total gain (+) or loss (−), $l+m$.
1900.						
Experiment No. 32.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Apr. 20–21, 7 a. m. to 7 a. m.	49.0	1.8	3.1	+ 44.1	− 18.0	+26.1
21–22, 7 a. m. to 7 a. m.	49.0	1.8	3.0	+ 44.2	− 92.2	−48.0
22–23, 7 a. m. to 7 a. m.	49.0	1.8	3.0	+ 44.2	−103.2	−59.0
Total, 3 days	147.0	5.4	9.1	+132.5	−213.4	−80.9
Average, 1 day	49.0	1.8	3.0	+ 44.2	− 71.1	−26.9
Experiment No. 34.						
Apr. 26–27, 7 a. m. to 7 a. m.	51.1	1.7	3.4	+ 46.0	− 38.5	+ 7.5
27–28, 7 a. m. to 7 a. m.	51.1	1.6	3.1	+ 46.4	− 50.8	− 4.4
28–29, 7 a. m. to 7 a. m.	51.1	1.7	3.2	+ 46.2	− 69.5	−23.3
Total, 3 days	153.3	5.0	9.7	+138.6	−158.8	−20.2
Average, 1 day	51.1	1.7	3.2	+ 46.2	− 52.9	− 6.7

TABLE 141.—*Gain or loss of protein* ($N \times 6.25$), *fat, and water—Metabolism experiments Nos. 32 and 34.*

Date.	(*a*) Nitrogen gained (+) or lost (−).	(*b*) Protein gained (+) or lost (−), $a \times 6.25$.	(*c*) Total carbon gained (+) or lost (−).	(*d*) Carbon in protein gained (+) or lost (−), $b \times 0.53$.	(*e*) Carbon, in fat etc., gained (+) or lost (−), $c-d$.	(*f*) Fat gained (+) or lost (−), $e \div 0.761$.
1900.						
Experiment No. 32.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Apr. 20–21, 7 a. m. to 7 a. m.	−1.4	− 8.7	+ 1.5	− 4.6	+ 6.1	+ 8.0
21–22, 7 a. m. to 7 a. m.	− .3	− 1.9	−33.2	− 1.0	−32.2	− 42.3
22–23, 7 a. m. to 7 a. m.	− .7	− 4.4	−55.9	− 2.3	−53.6	− 70.4
Total, 3 days	−2.4	−15.0	−87.6	− 7.9	−79.7	−104.7
Average, 1 day	− .8	− 5.0	−29.2	− 2.6	−26.6	− 34.9
Experiment No. 34.						
Apr. 26–27, 7 a. m. to 7 a. m.	−2.6	−16.3	−26.6	− 8.6	−18.0	− 23.7
27–28, 7 a. m. to 7 a. m.	−1.5	− 9.4	−37.9	− 5.0	−32.9	− 43.2
28–29, 7 a. m. to 7 a. m.	−1.6	−10.0	−34.2	− 5.3	−28.9	− 38.0
Total, 3 days	−5.7	−35.7	−98.7	−18.9	−79.8	−104.9
Average, 1 day	−1.9	−11.9	−32.9	− 6.3	−26.6	− 35.0

TABLE 141.—*Gain or loss of protein ($N \times 6.25$), fat, and water—Metabolism experiments Nos. 32 and 34*—Continued.

Date.	(*g*) Total hydrogen gained (+) or lost (−).	(*h*) Hydrogen in protein gained (+) or lost (−), $b \times 0.07$.	(*i*) Hydrogen in fat gained (+) or lost (−), $f \times 0.118$.	(*k*) Hydrogen in water, etc., gained (+) or lost (−), $g - (h+i)$.	(*l*) Water gained (+) or lost (−), $k \times 9$.
1900.					
Experiment No. 32.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Apr. 20–21, 7 a. m. to 7 a. m	+26.1	−0.6	+ 0.9	+25.8	+232.2
21–22, 7 a. m. to 7 a. m	−48.0	− .1	− 5.0	−42.9	−386.1
22–23, 7 a. m. to 7 a. m	−59.0	− .3	− 8.3	−50.4	−453.6
Total, 3 days	−80.9	−1.0	−12.4	−67.5	−607.5
Average, 1 day	−26.9	− .3	− 4.1	−22.5	−202.5
Experiment No. 34.					
Apr. 26–27, 7 a. m. to 7 a. m	+ 7.5	−1.1	− 2.8	+11.4	+102.6
27–28, 7 a. m. to 7 a. m	− 4.4	− .7	− 5.1	+ 1.4	+ 12.6
28–29, 7 a. m. to 7 a. m	−23.3	− .7	− 4.5	−18.1	−162.9
Total, 3 days	−20.2	−2.5	−12.4	− 5.3	− 47.7
Average, 1 day	− 6.7	− .8	− 4.1	− 1.8	− 15.9

TABLE 142.—*Income and outgo of energy—Metabolism experiments Nos. 32 and 34.*

Date.	(*a*) Heat of combustion of food eaten.	(*b*) Heat of combustion of feces.	(*c*) Heat of combustion of urine.	(*d*) Estimated heat of combustion of protein gained (+) or lost (−).	(*e*) Estimated heat of combustion of fat gained (+) or lost (−).	(*f*) Estimated energy of material oxidized in the body, $a-(b+c+d+e)$.	(*g*) Heat determined.	(*h*) Heat determined, greater (+) or less (−) than estimated, $g-f$.	(*i*) Heat determined, greater (+) or less (−) than estimated, $h \div f$.
1900.									
Experiment No. 32.	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Per ct.*
Apr. 20–21, 7 a.m. to 7 a.m.	3,487	142	129	− 35	+ 77	3,174	3,253	+ 79	+2.5
21–22, 7 a.m. to 7 a.m.	3,487	141	113	+ 3	− 404	3,634	3,551	− 83	−2.3
22–23, 7 a.m. to 7 a.m.	3,487	142	116	− 11	− 672	3,912	3,890	− 22	− .5
Total, 3 days	10,461	425	358	− 43	− 999	10,720	10,694	− 26	.....
Average, 1 day	3,487	142	119	− 14	− 333	3,573	3,565	− 8	− .2
Experiment No. 34.									
Apr. 26–27, 7 a.m. to 7 a.m.	3,493	126	131	− 79	− 226	3,541	3,568	+ 27	+ .7
27–28, 7 a.m. to 7 a.m.	3,493	125	125	− 40	− 413	3,696	3,633	− 63	−1.7
28–29, 7 a.m. to 7 a.m.	3,493	126	123	− 43	− 363	3,650	3,561	− 89	−2.4
Total, 3 days	10,479	377	379	−162	−1,002	10,887	10,762	−125	.....
Average, 1 day	3,493	126	126	− 54	− 334	3,629	3,587	− 42	−1.1

SUMMARY AND RESULTS OF THE EXPERIMENTS.

SCOPE OF THE INVESTIGATIONS.

Number of experiments and experimental days.—Between February, 1896, and April, 1900, inclusive, 34 experiments, covering a period of 114 days, were made with the respiration calorimeter.

The first four of these, covering a period of 21 days, were designated as experiments Nos. 1–4, and the results were published in a previous bulletin.[a] Nine of the 12 days covered by experiment No. 4, however, really comprised three separate experiments, distinguished from one another by difference in occupation of the subject; these, for convenience, may be designated as 4a, 4b, and 4c. In all these experiments (Nos. 1–4c) the income and outgo of nitrogen and carbon and the income of energy were determined, but the heat given off from the body was not measured. Since they show only the balance of income and outgo of matter, including the material excreted in the breath, they are termed "respiration" experiments.

The results of six other experiments, Nos. 5–10, covering a period of 24 days, have also been published.[b] In these, and all later experiments, the balance of income and outgo of nitrogen, carbon, hydrogen, and energy was determined, and they are, therefore, termed "respiration calorimeter" or "metabolism" experiments.

Of the remaining 24 experiments, 13, covering a period of 41 days, are reported in detail in the present bulletin; the results of the other 11 experiments, covering a period of 28 days, and belonging to another investigation, are reported elsewhere.[c]

Accordingly, the total number of respiration calorimeter experiments thus far decribed, including those in the present report, is 30, covering 93 days. Besides these, 14 experiments, covering 41 days, made in the winter and spring of 1900–1901, are now completed and nearly ready for publication, thus making 44 experiments, Nos. 4–48, covering 134 days, in which the balance of nitrogen, carbon, hydrogen, and energy has been directly measured. Adding the respiration experiments, included in Nos. 1–4c and covering 21 days, we have 48 experiments, covering 155 days, in which the balance of nitrogen and carbon was determined.

Each metabolism experiment, or series of experiments, was immediately preceded by a digestion experiment of several days' duration, in which the subject had the same diet as in the metabolism experiment, the purpose being to bring the body into approximate nitrogen

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 44.

[b] U. S. Dept. Agr., Office of Experiment Stations Buls. 63 and 69.

[c] Memoirs of the National Academy of Sciences, Vol. VIII, Sixth Memoir, 1902.

and carbon equilibrium before the beginning of the metabolism experiment proper, and at the same time to secure a more nearly accurate measure of the digestibility of the food. It is almost impossible to obtain exact nitrogen equilibrium since physiological factors, little understood and not easily controlled, cause more or less fluctuation in the elimination of nitrogen, even when the amount in the diet is uniform. These preliminary digestion experiments were generally of 4 days' duration. Experiments Nos. 1–4, however, were both preceded and followed by digestion periods of 3 days, while some later experiments were preceded by periods more or less than 4 days. In these preliminary digestion experiments the income and outgo of nitrogen were determined, so that the nitrogen metabolism was measured, and in this sense they are metabolism experiments, although they are not here so designated. There were altogether 44 digestion and nitrogen metabolism experiments which accompanied or made a part of the 34 experiments with the respiration calorimeter. They covered 201 days. Only a small number of the results of these digestion experiments, viz, those belonging to respiration experiments Nos. 1–4, have yet been published.

Questions studied.—Although the larger part of the seven years' work in connection with the respiration calorimeter in this laboratory has been devoted to the developing and perfecting of apparatus and experimental methods, yet during the progress of the inquiry a mass of data has accumulated and results bearing upon a variety of questions have been obtained. A proper discussion of the results would include a consideration of the following and other topics: (1) The kinds, amounts, and digestibility of the food; (2) the quantity and composition of the excretory products; (3) the daily elimination of water, carbon dioxid, and heat, and the rates of elimination at different periods of the day and under different conditions; (4) the kinds and amounts of material actually oxidized by the different subjects under different conditions of rest and work; (5) the estimated amounts of oxygen used and the estimated respiratory quotients; (6) the demands of different persons for nourishment under different conditions; (7) the functions of the different nutrients and their mutual replacing power, or the nutritive values of different food materials; (8) the energy of the food and of the material oxidized as compared with that given off from the body; and, finally (9), the general bearing of the results upon the metabolism of energy. A number of collateral topics would also call for discussion, such as (10) the effects of different conditions of food, rest, and work upon bodily temperature; (11) the composition of the air in the chamber as related to the rate of ventilation and the well-being of the occupant, and as bearing upon the general hygiene of ventilation, (12) details of the apparatus, and (13) methods of experimental inquiry.

While none of these topics can be discussed to the best advantage until the publication of further experimental data, or without due consideration of the results of research elsewhere, brief reference may be made to a few of them in order to illustrate some of the ways in which the experiments are throwing light upon the fundamental questions of the metabolism of matter and energy in the body, and consequently upon the general laws of nutrition. Accordingly, the data already reported are here used for a preliminary discussion of a number of problems of general interest. These include (1) food materials supplied and consumed and the difference in the amounts of nutrients demanded by men at rest and at work, (2) the elimination of water, (3) the elimination of carbon dioxid, (4) the elimination of energy, and (5) the income and outgo of energy and the action of the law of the conservation of energy in the body. The text-books and treatises bearing on these subjects contain more or less detailed statements and conclusions. It appears that in numerous instances the commonly quoted figures and conclusions rest upon much less experimental evidence than is furnished by the experiments with the respiration calorimeter just referred to. In the construction of this apparatus it was possible to make use of the experience and results of earlier investigators; the facilities have permitted the obtaining of more accurate and extensive data than had previously been practicable; and it is believed that the results are of sufficient interest to warrant their publication even though future research may call for more or less modification of the inferences deduced from them.

Brief summaries of results are given on the following pages. These results are derived from the statistics of experiments Nos. 5–11, 13, 14, 21, 23–26, 28, 29, 31, 32, and 34. The results summarized in Table 144, p. 129, include, in addition, the results of experiments Nos. 1–4, in which the outgo of energy was not determined.

Subjects of the experiments.—Four different men, E. O., O. F. T., A. W. S., and J. F. S., have served as subjects in these experiments. They were all in excellent health. E. O. was a laboratory assistant, a native of Sweden, who had been a number of years in this country. At the time of the experiments here recorded he was about 32 years old and weighed not far from 70 kilograms. A. W. S. was a physicist, a native of New England, 25 years old, and weighed about 70 kilograms. O. F. T., a chemist, the subject of but one experiment, No. 3, was also a native of New England, 24 years old, and weighed about 60 kilograms J. F. S., a chemist, was a native of Canada, 29 years old, and weighed about 65 kilograms.

Rest and work experiments.—In the rest experiments the subjects were as quiet as they well could be. Practically their only muscular exercise was that involved in dressing and undressing, folding and

unfolding the bed, chair, and table, eating, caring for the excretory products, and weighing themselves and the absorbers. They did more or less reading and writing to pass the time. In the work experiments they spent a number of hours, generally 8 each day, driving a stationary bicycle.[a] It was their purpose to do a reasonable but not excessive amount of work.

Experiments Nos. 1 and 2 with E. O., No. 3 with O. F. T., and Nos. 4a and 4b with A. W. S., were rest experiments, while No. 4c with A. W. S. was a work experiment. In none of these experiments were satisfactory determinations made of the outgo of energy. The experimental days began at different hours, and were not divided into 6-hour experimental periods, as was done in all experiments after No. 4c. Taking into account the 19 experiments, summarized in the following tables, in which the measurements of the outgo of energy were considered satisfactory, there were 9 rest experiments with E. O., covering 33 days; 1 rest experiment with A. W. S., covering 3 days, and 3 rest experiments with J. F. S., covering 9 days, making altogether 13 rest experiments, covering 45 days. There were also 2 work experiments with E. O., covering 8 days, and 4 work experiments with J. F. S., covering 12 days, making together 6 work experiments, covering 20 days. Altogether the 19 rest and work experiments covered a total period of 65 days. In addition, 9 rest experiments covering 22 days and 2 work experiments covering 6 days were completed during this time in connection with a separate investigation.

Division of experimental days into periods.—Each of these experiments is divided into days of 24 hours, beginning and ending at 7 a. m. Each day is divided into 4 periods of 6 hours each; the first 2, called day periods, extending from 7 a. m. to 1 p. m. and from 1 p. m to 7 p. m.; the last 2, called night periods, extending from 7 p. m. to 1 a. m. and from 1 a. m. to 7 a. m.

The chief reason for beginning the experimental day in the morning is found in the belief that the condition of the body in respect to the amounts of material in the alimentary canal and of carbohydrates (glycogen) and oxygen in the tissues and fluids would be more nearly the same, from day to day, at the end of the period of rest and sleep than at any other time.

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[a] Excepting in experiment No. 4b, in which the subject raised and lowered a weight attached to a rope which passed over a pulley.

SUMMARY OF RESULTS OF INDIVIDUAL EXPERIMENTS.

In Table 143, below, are summarized the results of the experiments made with the respiration calorimeter which have been thus far reported by this Department.[a] The table shows the balance of income and outgo of nitrogen, carbon, and energy, as well as the computed gain or loss of body protein and fat.

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[a] During the interval between the first and last of the experiments here reported nine experiments were carried on under the auspices of the Committee of Fifty for the Investigation of the Drink Problem in connection with an independent investigation concerning the effect of alcohol in the diet. For convenience in keeping laboratory records all the experiments were numbered consecutively. These experiments, in which alcohol formed a part of the diet, comprised Nos. 7, 10, 12, 15–20, 22, 27, 30, and 33. The details of the first two were published in U. S. Dept. Agr., Office of Experiment Stations Bul. 69; those of the remaining eleven will be found in the Memoirs of the National Academy of Sciences, Vol. VIII, Sixth Memoir, entitled An Experimental Inquiry into the Nutritive Value of Alcohol, 1902.

TABLE 143.—*Summary of income and outgo of nitrogen, carbon, and energy in 19 experiments, covering 65 days.*

Serial number.	Subject and kind of experiment.	Duration.	Nitrogen—				Carbon—					Body material.		Energy—								
			In food.	In feces.	In urine.	Gain (+) or loss (−).	In food.	In feces.	In urine.	In respiratory products.	Gain (+) or loss (−).	Protein, gain (+) or loss (−).	Fat, gain (+) or loss (−).	Of food.	Of feces.	Of urine.	Of body protein, gain (+) or loss (−).	Of body fat, gain (+) or loss (−).	Of material actually oxidized; net income.	Measured as heat; net outgo.	Difference between net income and net outgo.	
	REST EXPERIMENTS.	*Days.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Per cent.*
5	Subject E. O	4	19.1	1.7	18.1	−0.7	248.9	13.8	11.6	231.7	− 8.2	− 4.2	− 7.8	2,655	143	128	−24	− 73	2,482	2,379	−103	−4.1
7	.....do	4	16.7	.9	17.7	−1.9	217.1	6.7	13.3	214.5	−17.4	−12.0	−14.3	2,441	76	135	−69	−135	2,434	2,394	− 40	−1.6
8	.....do	4	20.8	1.3	19.5	0	270.7	10.6	13.9	224.5	+21.7	0	+28.3	2,897	117	153	0	+266	2,361	2,287	− 75	−3.2
9	.....do	4	19.1	1.3	18.4	− .6	261.6	13.4	12.6	223.6	+12.0	− 3.6	+18.2	2,717	142	149	−21	+171	2,277	2,309	+ 32	+1.4
10	.....do	4	19.8	1.4	19.5	−1.1	252.8	11.8	13.5	214.9	+12.6	− 6.9	+21.2	2,701	127	147	−40	+199	2,268	2,283	+ 16	+ .7
13	.....do	3	18.7	1.1	19.5	−1.9	245.8	11.1	15.1	205.2	+14.4	−11.7	+26.9	2,596	125	173	−67	+253	2,112	2,151	+ 39	+1.8
14	.....do	4	15.1	.9	16.2	−2.0	239.0	7.4	12.2	207.3	+12.1	−12.4	+24.5	2,513	82	142	−71	+229	2,131	2,193	+ 62	+2.9
23	.....do	3	19.8	1.1	19.0	− .3	244.9	10.2	12.2	216.4	+ 6.1	− 1.6	+ 9.0	2,546	114	141	− 9	+ 84	2,216	2,176	− 40	−1.8
24	.....do	3	19.8	1.3	18.2	+ .3	299.7	10.5	11.8	230.9	+46.5	+ 1.7	+59.7	3,061	116	136	+10	+561	2,238	2,272	+ 34	+1.5
	Average 9 experiments with E. O.	.....	18.8	1.2	18.5	− .9	253.4	10.6	12.9	218.8	+11.1	− 5.6	+18.4	2,681	116	145	−32	+173	2,280	2,272	− 8	−3.5
	Average 7 experiments with E. O. (omitting Nos. 7 and 10)	.....	18.9	1.2	18.4	− .7	258.7	11.0	12.8	219.9	+15.0	− 4.5	+22.7	2,712	120	146	−26	+213	2,260	2,252	− 7	−3.1
21	Subject A. W. S	3	15.5	1.0	15.4	− .9	215.2	9.0	10.8	217.4	−22.0	− 5.6	−24.9	2,264	100	126	−32	−234	2,304	2,279	− 25	−1.1
25	Subject J. F. S	3	17.7	1.0	16.4	+ .3	270.9	9.7	12.9	216.6	+31.7	+ 1.9	+40.4	2,896	111	147	+11	+385	2,242	2,244	+ 2	+ .1
26	.....do	3	15.9	1.1	15.4	− .6	233.2	9.4	11.0	196.1	+16.7	− 3.5	+24.4	2,490	106	128	−20	+233	2,043	2,085	+ 42	+2.0

28	.....do.....	3	15.8	1.2	15.3	− .7	245.8	10.0	10.9	210.7	+14.2	− 4.5	+21.8	2,489	112	128	−26	+208	2,067	2,079	+ 12	+ .6
	Average 3 experiments with J. F. S.....	.....	16.5	1.1	15.7	− .3	250.0	9.7	11.6	207.8	+20.9	− 2.0	+28.9	2,625	110	134	−12	+275	2,117	2,136	+ 19	+ .9
	Average 13 rest experiments with E. O., A. W. S., and J. F. S.	.....	18.0	1.2	17.6	− .8	249.7	10.3	12.4	216.1	+10.8	− 4.8	+17.5	2,636	113	141	−28	+165	2,244	2,241	− 3	− .1
	Average 11 rest experiments above (omitting Nos. 7 and 10 with E. O.)	.....	17.9	1.2	17.4	− .6	252.4	10.5	12.3	216.4	+13.2	− 4.0	+20.0	2,648	115	141	−23	+189	2,225	2,223	− 2	− .1
	WORK EXPERIMENTS.																					
6	Subject E. O.....	4	19.1	1.5	16.5	+1.1	336.7	12.4	12.5	345.2	−33.4	+ 6.9	−48.4	3,678	139	125	+40	−455	3,829	3,726	−103	−2.7
11	.....do.....	4	19.8	2.2	18.1	− .5	373.5	20.2	12.7	372.6	−32.0	− 3.0	−39.7	3,862	219	133	−17	−374	3,901	3,932	+ 31	+ .8
	Average 2 experiments with E. O.	.....	19.5	1.9	17.3	+ .3	355.1	16.3	12.6	358.9	−32.7	+ 2.0	−44.1	3,770	179	129	+12	−415	3,865	3,829	− 36	− .9
29	Subject J. F. S.....	3	16.0	.8	16.0	− .8	333.6	8.3	11.2	334.9	−20.8	− 5.0	−23.8	3,487	93	134	−28	−227	3,515	3,589	+ 74	+2.1
31	.....do.....	3	16.1	.8	15.6	− .3	321.5	8.1	10.9	315.8	−13.3	− 2.3	−15.9	3,495	91	129	−13	−151	3,439	3,420	− 19	− .6
32	.....do.....	3	16.1	1.2	15.7	− .8	320.0	12.6	11.0	325.6	−29.2	− 5.0	−34.9	3,487	142	119	−14	−333	3,573	3,565	− 8	− .2
34	.....do.....	3	16.0	1.2	16.7	−1.9	335.7	11.6	11.6	345.4	−32.9	−11.9	−35.0	3,493	126	126	−54	−334	3,629	3,487	−142	−1.2
	Average 4 experiments with J. F. S.....	.....	16.1	1.0	16.0	−1.0	327.7	10.2	11.2	330.4	−24.1	− 6.1	−27.4	3,491	113	127	−27	−261	3,539	3,540	+ 1	0
	Average 6 work experiments with E. O. and J. F. S.....	.....	17.2	1.3	16.4	− .5	336.8	12.2	11.7	339.9	−26.9	− 3.4	−33.0	3,584	135	128	−14	−312	3,647	3,637	− 10	− .3
	Average of all (19) rest and work experiments.....	.....	17.7	1.2	17.2	− .7	277.2	10.9	12.2	255.2	− 1.1	− 4.4	+ 1.6	2,936	120	137	−23	+ 14	2,688	2,682	− 6	− .2
	Average of 17 rest and work experiments (omitting Nos. 7 and 10).....	.....	17.7	1.2	18.3	− .6	282.2	11.1	12.1	283.1	− 1.0	− 3.8	+ 1.3	2,978	122	136	−19	+ 12	2,727	2,722	− 5	− .2

The experiments are grouped in Table 143 according to their character, whether rest or work, and subgrouped according to the person serving as subject. With E. O. there were made 9 rest experiments covering 33 days, of which two, Nos. 7 and 10, reported in an earlier bulletin of this Office[a] were made for a special purpose. In Table 143 the results are averaged both with and without these two experiments. One rest experiment was made with A. W. S. and 3 with J. F. S. In all these experiments the ration was determined as far as possible by the food requirements of the subject under the particular conditions. The amount of nitrogen in the food in the rest experiments with E. O. averaged 18.8, with A. W. S. 15.5, and with J. F. S. 16.5 grams per day. The amount metabolized was approximately in the same proportion. The amounts of carbon and energy in the food were also larger with E. O. than with the other subjects, but there was comparatively little difference in the amounts actually metabolized. The daily amount of energy averaged 2,280 calories with E. O., 2,304 with A. W. S., and 2,117 with J. F. S.

Two work experiments covering 8 days were made with E. O., and 4 covering 12 days with J. F. S. The quantity of nitrogen, carbon, and energy in the food and in the material actually oxidized was greater in the case of E. O. than J. F. S. The amount of muscular work performed was also larger. The quantity of nitrogen in the food and in the material actually metabolized was, however, not greatly different from the corresponding amounts in the rest experiments. The energy of material oxidized averaged 3,865 calories with E. O. and 3,547 calories with J. F. S. The agreement between the values for net income and net outgo differed through limits which are doubtless within the range of experimental error and physiological uncertainties.

Further discussion of the results obtained in the experiments will be found in the more general tables following.

FOOD MATERIALS SUPPLIED AND CONSUMED, AND THE DIFFERENCE IN DEMAND BY MEN AT REST AND AT WORK.

One of the objects of these experiments is to accumulate information regarding the demands of the body for food with different persons and under different conditions of rest and work. Data bearing upon these questions are found in all of the experiments. The detailed tables show the total amounts and the composition of the food, drink, and excretory products. The figures in Table 144 summarize very briefly some of the principal results.

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[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 69.

TABLE 144.—*Income and outgo of material in the body, and gains and losses of protein and fat with different diets—Amounts per day.*

Subject, duration, and character of experiment.	Nitrogen.	Carbon.	Energy.	Protein (N×6.25).	Fat.
REST EXPERIMENTS.					
E. O., 11 experiments, 37 days, average:	*Grams.*	*Grams.*	*Calories.*	*Grams.*	*Grams.*
In digested food	17.7	231.5	2,459	111	.....
In material oxidized	18.5	218.6	2,297	116	.....
Gain (+) or loss (−) in body	− .8	+ 12.9	.....	− 5	+ 20
O. F. T., 1 experiment, 5 days, average:					
In digested food	14.4	216.5	2,442	90	.....
In material oxidized	13.7	219.9	2,505	86	.....
Gain (+) or loss (−) in body	+ .7	− 3.4	.....	+ 4	− 7
A. W. S., 3 experiments, 9 days, average:					
In digested food	14.7	214.3	2,344	92	.....
In material oxidized	13.7	229.1	2,293	86	.....
Gain (+) or loss (−) in body	+ 1.0	− 14.8	.....	+ 6	− 24
J. F. S., 3 experiments, 9 days, average:					
In digested food	15.4	228.7	2,381	96	.....
In material oxidized	15.7	207.8	2,117	98	.....
Gain (+) or loss (−) in body	− .3	+ 20.9	.....	− 2	+ 29
E. O., O. F. T., A. W. S., J. F. S., 18 experiments, 60 days, average:					
In digested food	16.6	227.3	2,428	104	.....
In material oxidized	16.9	218.7	2,285	106	.....
Gain (+) or loss (−) in body	− .3	+ 8.6	.....	− 2	+ 13
WORK EXPERIMENTS.					
E. O., 2 experiments, 8 days, average:					
In digested food	17.6	326.2	3,462	110	.....
In material oxidized	17.3	358.9	3,865	108	.....
Gain (+) or loss (−) in body	+ .3	− 32.7	.....	+ 2	− 43
A. W. S., 1 experiment, 3 days, average:					
In digested food	14.8	223.6	2,505	92	.....
In material oxidized	14.1	371.5	4,325	88	.....
Gain (+) or loss (−) in body	+ .7	−147.9	.....	+ 4	−196
J. F. S., 4 experiments, 12 days, average:					
In digested food	15.0	306.4	3,251	94	.....
In material oxidized	16.0	330.4	3,547	100	.....
Gain (+) or loss (−) in body	− 1.0	− 24.0	.....	− 6	− 27
E. O., A. W. S., J. F. S., 7 experiments, 23 days, average:					
In digested food	15.9	302.5	3,227	99	.....
In material oxidized	16.2	345.7	3,759	101	.....
Gain (+) or loss (−) in body	− .3	− 43.2	.....	− 2	− 55

By "digestible food" or "digested food" is understood the total food less the feces—in other words, the sum of the nutrients which are available to the body for the building of tissue and yielding energy. No correction is introduced for metabolic products in the feces, since these were derived originally from the food (or body tissue) and are a

necessary accompaniment of undigested material. The available energy of the food is the total heat of combustion of the food minus the heat of combustion of the unoxidized materials of feces and urine. No further correction for the labor of chewing and digesting is included. It is assumed that the quantity of carbohydrates in the body is the same at the beginning as at the end of the experiment. The gains and losses of body protein and body fat are computed from the gains and losses of the nitrogen and carbon.[a] Accordingly the figures show the average daily amounts of available protein and energy supplied by the food and the amounts actually used by the body when the subject had a minimum amount of exercise and when he was engaged in decidedly active muscular work.

The materials actually oxidized in the body are the digested nutrients of the food minus the protein or fat gained or plus the protein or fat lost by the body. The data thus show very clearly the demands of the body under the different conditions and the increase in the demand which accompanied the performance of muscular work.

These experiments simply show the quantities of material and energy metabolized by a small number of men under specific conditions of work and rest. Their bearing upon the general subject of dietary standards can be more advantageously discussed when it is possible to take into account not only these and other experiments with men in the respiration calorimeter, but also a large number of experimental inquiries and observations of dietary usage of people of different classes and occupations in different countries.

There is no doubt that in many cases the body can be maintained in nitrogen and carbon equilibrium with much smaller quantities of nitrogen and energy than those actually used by any of the men in these experiments. It is equally certain that in other cases the requirements are much larger. The tentative standards for daily diet which have been proposed by a number of investigators have served a useful purpose, but they will doubtless have to be modified as the fundamental data become more exact and numerous.

One principle which thus far has not received adequate recognition in dietary standards may perhaps be expressed by saying that the standard must vary not only with the conditions of activity and environment, but also with the nutritive plane at which the body is to be maintained. A man may live and work and maintain bodily equilibrium on either a higher or lower nitrogen level or energy level. One essential question is, What level is most advantageous? The answer to this must be sought not simply in metabolism experiments and dietary studies, but also in broader observations regarding bodily and mental efficiency and general health, strength, and welfare.

[a] By the method previously described, U. S. Dept. Agr., Office of Experiment Stations Bul. 69, pp. 44, 45.

ELIMINATION OF WATER.

The water taken into the body in the food and drink and formed within it by the oxidation of hydrogen is excreted by the kidneys, lungs, and skin. The amount eliminated by the kidneys varies with the amounts taken in the food and drink and eliminated in the respiration and perspiration, and is, in consequence, very irregular. The amount of water given off by the lungs and skin appears to depend largely upon the muscular activity of the subject and the temperature of the surrounding air, and to be less affected by the income in food and drink.

Income and outgo of water per day.—Table 145 recapitulates the figures for the average amounts of water taken in the food and drink and eliminated in the various excretions in the 19 experiments, Nos. 5–11, 13, 14, 21, 23–26, 28, 29, 31, 32, and 34. In all these experiments the days were divided into 6-hour periods.

TABLE 145.—*Daily income and outgo of water.*

Subject and kind of experiment.	Days covered by experiments.	Income.			Outgo.			
		In food.	In drink.	Total.	In feces.	In urine.	In respiration and perspiration.	Total.
REST EXPERIMENTS.								
E. O., 9 experiments:		*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Minimum		653	1,023	1,945	35	1,037	697	2,015
Maximum		1,270	1,872	3,047	98	3,120	1,212	4,306
Average	33	1,037	1,407	2,444	59	1,810	977	2,846
A. W. S., 1 experiment:								
Minimum		890	1,384	2,274	46	1,628	821	2,496
Maximum		890	1,385	2,275	46	1,909	898	2,853
Average	3	890	1,385	2,275	46	1,743	859	2,648
J. F. S., 3 experiments:								
Minimum		1,040	800	1,840	19	913	791	1,811
Maximum		1,078	900	1,978	57	1,489	879	2,345
Average	9	1,055	833	1,888	52	1,219	830	2,101
Average of 13 experiments	45	1,031	1,291	2,322	57	1,687	939	2,684
WORK EXPERIMENTS.								
E. O., 2 experiments:								
Minimum		951	1,200	2,151	91	815	1,762	2,912
Maximum		1,384	2,100	3,079	100	1,275	2,699	3,981
Average	8	1,168	1,603	2,771	96	1,011	2,275	3,382
J. F. S., 4 experiments.								
Minimum		916	1,250	2,166	36	641	1,197	2,201
Maximum		1,036	1,250	2,286	72	1,433	2,094	3,215
Average	12	975	1,250	2,225	52	905	1,670	2,627
Average of 6 experiments	20	1,052	1,391	2,443	70	947	1,912	2,929

The averages given are those for all of the days of the experiments of the given group rather than averages of the average results of the individual experiments. It is to be remembered that there was considerable milk in the daily diet, and this is reckoned as food rather

than drink. How the amounts of water in food and drink in these experiments would compare with those in the average diet in general it is impossible to say for lack of sufficient data. The average daily amount of water in food and drink together in the rest experiments was for E. O. 2,444 grams, for A. W. S. 2,275 grams, and for J. F. S. 1,888 grams. In the work experiments with E. O. it was 2,771 grams, and with J. F. S. 2,225 grams.

The amount of urine excreted per day in the rest experiments averaged with E. O. 1,878 grams, containing 1,810 grams of water; with A. W. S. 1,798 grams, containing 1,743 grams of water, and with J. F. S. 1,266 grams, containing 1,219 grams of water. The average for the 45 days of the rest experiments with the three subjects was 1,750 grams of urine, containing 1,687 grams of water. In the work experiments the amount of urine excreted averaged with E. O. 1,081 grams, containing 1,011 grams of water, and with J. F. S. 961 grams, containing 905 grams of water. The average for the 20 days of work experiments with both subjects was 1,009 grams of urine, containing 947 grams of water.

The variations in the amounts excreted from day to day in experiments of the same kind with the same man were very wide. Thus in the rest experiments with E. O. the urine fell on one day to 1,091 grams, with 1,037 grams of water, while on another day it rose to 3,208 grams with 3,120 grams of water. It is to be observed that these experiments were made at different times during a period of two years, and covered in all 33 days. In the rest experiments with A. W. S., on the other hand, there is but one experiment, covering 3 days. Although the quantities of water in the food and drink were almost exactly the same from day to day, the quantities of urine and water in the urine were irregular, the range being from 1,681 grams of urine, with 1,628 grams of water, to 1,965 grams, with 1,909 grams of water. In the rest experiments with J. F. S. the quantities ranged from 975 grams of urine, containing 913 grams of water, to 1,551 grams of urine, containing 1,489 grams of water. These extremes occurred respectively on the first and third days of the first experiment with this subject.

In the work experiments with E. O., made at intervals of over a year, the water of food and drink ranged from 2,151 to 3,079 grams per day. There were corresponding variations in the amount of urine and of water in the urine, though the range was not wide, the minimum amount of urine being 879 grams, with 815 grams of water, and the maximum 1,350 grams, with 1,275 grams of water. In the work experiments with J. F. S., which were made at short intervals during the same year, the water of food and drink ranged from 2,166 to 2,286 grams, and the variation in the amount of urine per day was from 695 grams of urine, containing 641 grams of water, to 1,488 grams of urine, containing 1,433 grams of water.

In comparing the averages of the rest and work experiments with both subjects E. O. and J. F. S., it will be observed that while the quantity of water in the food and drink was considerably larger in the work than in the rest experiments, the amounts of urine and water in the urine was larger in the latter than in the former. The differences, however, varied with the two subjects. Thus with E. O. the total income of water was over 10 per cent larger in the work than in the rest experiments, but the outgo in the urine was but little over half as large in the former as in the latter. With J. F. S. the total income in the work experiments was nearly 20 per cent larger than in the rest experiments, but the outgo in the urine was only three-fourths as large in the former as in the latter. With both subjects the amount of solids in the urine was slightly larger in the work than in the rest experiments.

Elimination of water by respiration and perspiration.—The differences in the elimination of water in the urine in the rest experiments as compared with the work experiments find a ready explanation in the figures for water in the respiration and perspiration. The amounts of water thus eliminated by E. O. averaged 2,275 grams in the work experiments as compared with 977 grams in the rest experiments; and by J. F. S., 1,670 grams in the work experiments as compared with 830 grams in the rest experiments. In other words, the water eliminated by the kidneys depends, of course, upon the ratio of water in the food and drink to water of respiration and perspiration. The kidneys rid the body of the water not thrown off by the lungs and skin.

It is commonly assumed that the expired air is saturated with moisture. Supposing this to be a fact, the quantity of water given off from the lungs would be proportional to the amount of expired air. In times of active muscular exercise the volume of this air is larger than in times of rest, and consequently the amount of water given off from the lungs would be larger. Furthermore, the perspiration from the skin increases greatly with the muscular activity. With E. O. the amount of water excreted per day from the lungs and skin in the work experiments was 2⅛ times as large as in the rest experiments. With J. F. S. it was twice as large in the work as in the rest experiments.

The balance of income and outgo of water is decided not only by the amounts in food and drink on the one hand, and by the kidneys, lungs, and skin on the other, but also by two other factors. One of these is the amount of water formed within the body by the oxidation of hydrogen. The other is the change in the amount of water in the alimentary canal and in the tissues and fluids of the body. The discussion of this topic is reserved until additional data, which are being accumulated, are available.

One point, however, is so interesting that a word regarding it may be in place here. Comparisons of figures for amounts of hydrogen oxidized, as given in the tabular details of the experiments, show that if all the water formed by the oxidation of the hydrogen of the food and body material were eliminated through the lungs and skin and none through the kidneys, it would account for only about one-third of the water of respiration in the rest experiments and only about one-fourth of that in the work experiments. It is therefore evident that the increase of water of respiration and perspiration during periods of muscular activity is due not so much to an increased oxidation of hydrogen as to an increased excretion through the lungs and skin of water from some other source.

The amounts of water eliminated by the lungs and skin in the different periods of the day, as compared with the day as a whole, are shown in Table 146.

TABLE 146.—*Water eliminated by lungs and skin—Amounts per day, and rates and proportions for different periods.*

Subject and kind of experiment.	Days covered by experiments.	Total amount in 24 hours.	Rate per hour.					Proportion of total for 24 hours.			
			Day periods.		Night periods.		Average for 24 hours.	Day periods.		Night periods.	
			7 a. m. to 1 p. m.	1 p. m. to 7 p. m.	7 p. m. to 1 a. m.	1 a. m. to 7 a. m.		7 a. m. to 1 p. m.	1 p. m. to 7 p. m.	7 p. m. to 1 a. m.	1 a. m. to 7 a. m.
REST EXPERIMENTS.											
E. O., 9 experiments:		*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Minimum	....	697	32.0	23.4	30.4	23.4	29.0	.....	.....	.....	.....
Maximum	....	1,212	55.9	56.4	57.7	50.3	50.5	.....	.....	.....	.....
Average	33	977	39.1	41.8	43.7	38.2	40.7	24.0	25.7	26.8	23.5
A. W. S., 1 experiment:											
Minimum	....	821	35.0	35.2	34.8	31.8	34.2	.....	.....	.....	.....
Maximum	....	898	37.5	37.9	39.3	34.9	37.4	.....	.....	.....	.....
Average	3	859	36.3	36.2	37.4	33.3	35.8	25.3	25.3	26.1	23.3
J. F. S., 3 experiments:											
Minimum	....	791	33.7	34.6	33.1	30.0	32.9	.....	.....	.....	.....
Maximum	....	879	38.9	39.4	39.8	32.8	36.6	.....	.....	.....	.....
Average	9	830	36.0	36.0	35.2	31.1	34.6	26.0	26.0	25.5	22.5
Average of 13 experiments	45	939	38.3	40.3	41.6	36.4	39.1	24.5	25.7	26.6	23.2
WORK EXPERIMENTS.											
E. O., 2 experiments:											
Minimum	....	1,762	89.2	69.4	56.8	49.7	73.4	.....	.....	.....	.....
Maximum	....	2,699	147.1	153.0	107.7	77.2	112.5	.....	.....	.....	.....
Average	8	2,275	120.3	108.5	85.6	64.8	94.8	31.7	28.6	22.6	17.1
J. F. S., 4 experiments:											
Minimum	....	1,197	66.8	67.1	31.7	30.8	49.9	.....	.....	.....	.....
Maximum	....	2,094	134.5	140.2	38.4	37.3	87.3	.....	.....	.....	.....
Average	12	1,670	98.5	111.5	34.8	33.5	69.6	35.4	40.1	12.5	12.0
Average of 6 experiments	20	1,912	107.2	110.3	55.1	46.0	79.7	33.7	34.6	17.3	14.4

In the rest experiments with E. O. the total amount of water of respiration and perspiration per day ranged from 697 to 1,212, and averaged 977 grams. Comparing the 12 hours of the day with the 12 hours of the night the amounts of water eliminated were practically the same, being, respectively, 49.7 and 50.3 per cent of the whole. Comparing by periods the largest elimination, 43.7 grams per hour, was in the first night period (7 p. m. to 1 a. m.) and the smaller, 38.2 grams per hour, in the last night period (1 a. m. to 7 a. m.), but the differences in the different periods were not large. The amounts with A. W. S. were somewhat smaller, the average daily elimination being 859 grams. Here, again, it was equally divided between the day and the night, and the amounts in the 6-hour periods differed but little, although the amount in the first night period was slightly larger than that in the second night period, the latter being little smaller than in either of the day periods, as was the case with E. O. The average daily elimination with J. F. S., 830 grams, was still less than with A. W. S. In this case the elimination was somewhat larger during the day than during the night periods, being 52 per cent of the whole for the former as compared with 48 per cent for the latter. The average for both the day periods was the same, 36 grams. As was the case with the two other subjects, the average for the first night period was larger than that for the second. Taking the rest of the experiments with the 3 subjects together the daily average for 45 days was 939 grams, or 39.1 grams per hour. The amounts per hour in the 4 periods were, respectively, 38.3, 40.3, 41.6, and 36.4 grams, or 24.5, 25.7, 26.6, and 23.2 per cent of the total for the day.

In the work experiments in which the subjects E. O. and J. F. S. were engaged in active muscular work 8 hours each day between 7 a. m. and 7 p. m., the average daily outgo of water through lungs and skin was increased to 1,912 grams per day. With E. O. this increase is noticeable in all 4 periods, but is especially marked in the first day period, the average in that period being 3 times as great in the work as in the rest experiment. In the majority of cases the amount gradually fell off during the subsequent periods; but even during the last night period the average was nearly 1¾ times as large for the work as for the rest experiments. Of the total daily amount 60.3 per cent was given off during the two day periods, and 39.7 per cent during the two night periods. With J. F. S. there was an increase in elimination during the day periods only, being most noticeable in the second, in which it was 3 times as large in the work as in the rest experiments. The elimination during the night periods was practically the same in the work as in the rest experiments. Of the total daily amount eliminated by this subject in the work experiments 75.5 per cent was given off during the two day periods and 24.5 per cent during the two night periods. In the average of the experiments

with the two subjects the amounts for the 4 periods were, respectively, 107.2, 110.3, 55.1, and 46 grams per hour, or 33.7, 34.6, 17.3, and 14.4 per cent of the total.

The parallelism between muscular work and increased water elimination by the lungs and skin is not close, nor does the increase coincide at all with the period of work. The "lag" in elimination of water, i. e., the length of time between its ingestion in food and drink or its formation by the oxidation of hydrogen on the one hand and its elimination by various channels on the other is decided by factors too complex for full discussion here, and must be discussed in the light of later experiments.

ELIMINATION OF CARBON DIOXID.

The carbon dioxid given off from the body is derived from the oxidation of the carbon of the food and body material, and hence serves as a measure of the amount of that oxidation. The quantity given off in the urine and feces is very small indeed. It is here neglected, and that given off by the lungs and skin is taken as representing the total elimination. The quantity eliminated in a given period depends upon a variety of conditions, among which are (1) the character of the diet and the time which has elapsed since the last meal was taken, (2) the muscular activity of the subject—whether at rest or at work, (3) the external temperature, (4) the age and body weight, and (5) individual peculiarities of the subject. The accuracy with which the carbon dioxid eliminated for a given period measures the production for that period depends upon the so-called "lag" in the elimination, a topic to be discussed in another place.

In the experiments here reported there are considerable fluctuations in the output. Of the factors which cause these fluctuations, the most important is the muscular activity. The differences in the food were mainly those called for by the differences in the muscular exercise. The external temperature, i. e., that of the air in the chamber, was kept as nearly 20° C. as convenient. The subjects were young, healthy, active men, of similar age, height, and weight, but differing slightly in the amounts of food to which they were accustomed, so that there was nothing to imply differences in personal characteristics so great as to affect materially the oxidation of carbon.

The figures for the daily elimination of carbon dioxid are summarized in Table 147, which shows the average amount per hour during each period and for the whole day and the percentage which the output for each period makes of the average amount for twenty-four hours.

TABLE 147.—*Carbon dioxid eliminated by lungs and skin—Amounts per day, and rates and proportions in different periods.*

Subject and kind of experiment.	Days covered by experiments.	Total amount in 24 hours.	Rate per hour.					Proportion of total for 24 hours.			
			Day periods.		Night periods.		Average for 24 hours.	Day periods.		Night periods.	
			7 a. m. to 1 p. m.	1 p. m. to 7 p. m.	7 p. m. to 1 a. m.	1 a. m. to 7 a. m.		7 a. m. to 1 p. m.	1 p. m. to 7 p. m.	7 p. m. to 1 a. m.	1 a. m. to 7 a. m.
REST EXPERIMENTS.											
E. O., 9 experiments:		*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Per. ct.*	*Per. ct.*	*Per. ct.*	*Per. ct.*
Minimum	....	739	32.7	33.2	31.2	20.4	30.8	.....	.....	.....	.....
Maximum	....	879	43.2	42.8	42.2	25.6	36.6	.....	.....	.....	.....
Average	33	803	37.9	37.4	36.2	22.3	33.9	28.3	28.0	27.1	16.6
A. W. S., 1 experiment:											
Minimum	....	787	38.1	35.9	30.9	21.8	32.8	.....	.....	.....	.....
Maximum	....	816	41.5	38.2	33.7	24.3	34.0	.....	.....	.....	.....
Average	3	797	39.8	37.1	32.8	23.2	33.2	29.9	27.9	24.7	17.5
J. F. S., 3 experiments:											
Minimum	....	715	33.4	33.2	28.1	21.2	29.8	.....	.....	.....	.....
Maximum	....	801	39.7	40.1	36.3	23.3	33.4	.....	.....	.....	.....
Average	9	762	37.0	36.1	31.6	22.3	31.8	29.1	28.4	24.9	17.6
Average of 13 experiments	45	794	37.8	37.2	35.0	22.4	33.1	28.6	28.1	26.4	16.9
WORK EXPERIMENTS.											
E. O., 2 experiments:											
Minimum	....	1,195	69.4	65.0	33.9	19.9	49.8	.....	.....	.....	.....
Maximum	....	1,510	90.2	98.2	42.2	26.2	62.9	.....	.....	.....	.....
Average	8	1,316	78.4	79.5	38.4	23.1	54.8	35.7	36.3	17.5	10.5
J. F. S., 4 experiments:											
Minimum	....	1,080	63.4	61.9	27.8	21.0	45.0	.....	.....	.....	.....
Maximum	....	1,292	81.0	79.8	36.2	24.1	53.9	.....	.....	.....	.....
Average	12	1,212	73.6	74.7	31.3	22.3	50.5	36.5	37.0	15.5	11.0
Average of 6 experiments	20	1,253	75.5	76.6	34.1	22.6	52.2	36.2	36.7	16.3	10.8

The elimination of carbon dioxid under conditions of rest averaged 803 grams per day, or 33.9 grams per hour, in the 33 experimental days of the 9 experiments with E. O.; 797 grams per day, or 33.2 grams per hour, in the 3 experimental days of one experiment with A. W. S., and 762 grams per day, or 31.8 grams per hour in the 9 experimental days of 3 experiments with J. F. S. The range was from 739 to 879 grams per day with E. O., from 787 to 816 with A. W. S., and from 715 to 801 with J. F. S. It will be remembered, however, that the experiments with E. O. were made at different times during two years, while those with A. W. S. were in a single experiment. Those with J. F. S. were made at short intervals during the same year. In 8 experimental days of the 2 experiments in which the subject E. O. was engaged in active muscular work for 8 hours each day the output averaged 1,316 grams per day, or 54.8 grams per hour, while in 12 experimental days in which the subject J. F. S. was similarly engaged it was 1,212 grams per day, or 50.5 grams per hour.

During the rest experiments, in which the subjects had as little muscular activity as possible, there was but little difference in the elimination of carbon dioxid during the two day and first night periods. In the 9 experiments with E. O. the average rate per hour during these three periods was 37.9, 37.4, and 36.2 grams, respectively. In the experiment with A. W. S. there was a slightly larger amount of carbon dioxid eliminated in the first two periods than in the third period, the rates being 39.8, 37.1, and 32.8 grams, respectively. In the 4 experiments with J. F. S. the elimination during the first three periods averaged 37, 36.1, and 31.6 grams per hour, respectively. During the second night period, when the subject was generally asleep for nearly the whole time, the output fell off with E. O. to 22.3, with A. W. S. to 23.2, and with J. F. S. to 22.3 grams per hour. Not only are the averages with the 3 men in close accord, but the range of variation in the different days and experiments is decidedly narrow for all. In the average of the 13 experiments the proportion given off in each of the four periods of the day is 28.6, 28.1, 26.4, and 16.9 per cent, respectively.

The elimination of carbon dioxid in the two day periods of the work experiments was more than twice as large as in the two day periods of the rest experiments. With E. O. the average amounts given off were 78.4 grams in the first and 79.5 in the second day period when at work, as compared with 37.9 and 37.4 grams, respectively, when at rest. With J. F. S. the amounts averaged 73.6 and 74.7 grams in the day periods of the work experiments, as compared with 37 and 36.1 grams in the corresponding periods of the rest experiments. The elimination in the two night periods averaged with E. O. 38.4 and 23.1 grams in the work experiments, as compared with 36.2 and 22.3 grams in the rest experiments, the differences being small; with J. F. S. the amounts were practically identical, being 31.3 and 22.3 grams in the work experiments, as compared with 31.6 and 22.3 grams in the rest experiments.

The uniformity in the amounts of carbon dioxid given off during the second night period in all the experiments is very noticeable. Such data may perhaps be taken as an approximate measure of the metabolism of carbon in the body of an active healthy man when at its lowest ordinary ebb.

ELIMINATION OF ENERGY.

Measurements of energy.—The kinetic energy given off by the body is measured in these experiments as the sum of three quantities: (1) The heat taken up by the water current in its passage through the chamber; (2) the latent heat of the water vapor given off by the body—i. e., of the water vaporized by its heat and carried out in the air current,

due corrections being made for water condensed upon the absorbers; and (3) the heat equivalent of the muscular work done.

In the measurements of energy of income and outgo of the body the temperature of the interior of the chamber, generally about 20 degrees, is taken as the basis for computations of the heat removed or given off by food, drink, and excretory products in the chamber.[a]

(1) The heat carried away by the water current includes (*a*) the heat given off from the skin by radiation and conduction; (*b*) that brought out of the body in the feces and urine and given off in the cooling of these excretory products to the temperature of the chamber; (*c*) that brought out of the body in the air, carbon dioxid, and water excreted by the lungs and skin and given off in their cooling to the same temperature; (*d*) the latent heat of vaporization of so much of the water of *c* as is permanently condensed on the absorbers (mainly collected as drip water); and (*e*) the heat produced by the transformation of the external muscular work. The heat of *a*, *b*, *c*, and *e* finds its way by radiation and conduction to the surface of the copper absorbers and passes with that of *d* into the water current by which it is carried out of the chamber.

(2) Although the air current enters and leaves the chamber at the same temperature, it carries out more heat than it brings in. The extra heat carried out is the latent heat of the water vapor added to the air of the chamber by the subject.[b] The amount of this heat is learned from the amount of water vapor and its latent heat of vaporization at the given temperature.

(3) The external muscular work is measured and the heat equivalent calculated. Before leaving the chamber it is transformed into heat, which is carried away by the water current as above stated.

Energy given off in different ways as heat and as external muscular work.—The average amounts of energy given off by the body per day in the different ways are shown in Table 148.

The figures in the second column are obtained by subtracting the sum of the quantities of heat given off by the feces and urine in cooling and by the water in condensing on the absorbers and the heat equivalent of the external work ($b + d + e$ above) from the total heat taken from the chamber by the water current. Accordingly they represent the sum of quantities of heat given off by the skin directly and by the product of respiration and perspiration in cooling to the temperature of the room ($a + c$ above). It is hoped that it will be possible later to make at least approximate estimates of the latter quantity and thus show the amount of heat given off by the skin alone.

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 69, p. 20.

[b] The differences in specific heat of the air due to loss of oxygen and gain of carbon dioxid are here assumed to be negligible.

TABLE 148.—*Energy given off by the body in different ways—Amounts per day.*

Subject and kind of experiment.	Days covered by experiments.	Heat eliminated.			Heat equivalent of muscular work.	Total.
		By radiation and conduction.	In urine and feces.	In water vaporized from lungs.		
REST EXPERIMENTS.						
E. O., 9 experiments:		*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*
Minimum		1,479	19	412		2,062
Maximum		1,835	56	715		2,452
Average	33	1,675	33	570		2,278
A. W. S., 1 experiment:						
Minimum		1,710	30	486		2,226
Maximum		1,782	34	531		2,348
Average	3	1,739	31	509		2,279
J. F. S., 3 experiments:						
Minimum		1,564	17	468		2,065
Maximum		1,759	27	520		2,297
Average	9	1,622	23	491		2,136
Average of 13 experiments	45	1,669	31	550		2,250
WORK EXPERIMENTS.						
E. O., 2 experiments:						
Minimum		2,045	17	1,041	193	3,473
Maximum		2,521	25	1,560	270	4,287
Average	8	2,249	20	1,332	228	3,829
J. F. S., 4 experiments:						
Minimum		2,185	13	709	127	3,253
Maximum		2,400	27	1,240	277	3,890
Average	12	2,296	18	988	238	3,540
Average of 6 experiments	20	2,277	19	1,126	234	3,656

The figures for the heat given from the urine and feces, as shown in the third column in Table 148, are calculated from the weights of these excreta, their fall in temperature, and their specific heats. The weights are found by the balance. The fall in temperature is the difference between the temperature of the body and that of the interior of the chamber. This difference averages about 17 degrees. The specific heats are arbitrarily assumed, that of feces being taken as 0.9 and of urine 1.0.

The figures in the fourth column represent the latent heat of vaporization of the water given off by the lungs and skin. For the rest experiments this water is in general that carried out of the chamber in the air current in excess of that brought into the chamber by the same current. In a few rest experiments, however, and in all the work experiments more or less water is condensed on the absorbers and is not carried out by the air current. The figures in the third column include the heat given off in the condensation of this water vapor upon the absorbers, along with the latent heat of vaporization of the water in the air current. The reason why little or no water was condensed on the surfaces of the absorbers in the rest experiments is

that the temperature of the incoming water current was as a rule above the dew point of the air inside the chamber.

The fifth column shows the heat equivalent of the external muscular work done in the work experiments. It is measured by the bicycle-dynamo apparatus by which the mechanical work is transformed into electrical energy and into heat.

According to the figures of Table 148, in the 45 days of the 13 rest experiments the average amounts of heat given off per day from the skin (together with that in the expired air) was 1,669, in urine and feces 31, and in the water evaporated from the lungs and skin 550 calories, making the whole daily elimination 2,250 calories. With E. O. the range in total heat eliminated was from 2,062 to 2,452 and the average 2,278 calories. With A. W. S. the range was from 2,226 to 2,348 and the avereage 2,279 calories. With J. F. S. the range was from 2,065 to 2,297 and the average 2,136 calories. Taking into account the experiments with all the subjects, the average amounts of heat given off in different ways may be expressed in percentages as follows:

TABLE 149.—*Percentages of total energy given off from the body in different ways.*

Heat.	In rest experiments.	In work experiments.
	Per cent.	*Per cent.*
From skin by radiation and conduction (and in exhaled air)	74.2	62.3
In urine and feces	1.4	.5
In water vaporized from lungs and skin	24.4	30.8
Heat equivalent of external muscular work done	.....	6.4
Total	100.0	100.0

Energy given off from the body in different periods of the day.—Table 150 summarizes the data for the outgo of energy during the different periods of the day in the 13 experiments covering 45 experimental days. As in the two previous tables, the figures for heat eliminated include (1) the quantity given off from the body and measured by the calorimeter; (2) that given off in the water vaporized during the same periods—i. e., carried away from the body in water vapor; and (3) the heat equivalent of the external muscular work done. The temperature of the body and the amount of material it contains varies somewhat from time to time.[a] It is assumed that at the hour when the experimental day begins and ends—7 a. m.—they will be very nearly the same from day to day. If they are the same at these times, the total quantity of heat in the body at the beginning and end of each experimental day will be the same. The total quantity of energy given off

[a] In order to obtain more accurate data regarding variations of body temperature and corresponding changes in the store of energy in the body from hour to hour, special apparatus has been devised for measuring the temperature of the body. See Arch. Physiol. [Pflüger], 88 (1901), No. 9–10, p. 492.

from the body during the day will in this case be equivalent to the total amount liberated within the body and will be closely parallel with the amounts of carbon and hydrogen oxidized. Taking each of these four periods of the day by itself, the differences between the amounts of heat stored in the body at the beginning and end will probably be larger than is the case for the whole day. For individual periods, therefore, the parallelism between the amounts of carbon oxidized and heat given off will hardly be as close as for the whole day.

TABLE 150.—*Heat given off by body, including for the work experiments the heat equivalent of the external muscular work—Amounts per day and rates and proportions for different periods.*

Subject and kind of experiment.	Days covered by experiments.	Total amount in 24 hours.	Rate per hour.					Proportion of total for 24 hours.			
			Day periods.		Night periods.		Average for 24 hours.	Day periods.		Night periods.	
			7 a. m. to 1 p. m.	1 p. m. to 7 p. m.	7 p. m. to 1 a. m.	1 a. m. to 7 a. m.		7 a. m. to 1 p. m.	1 p. m. to 7 p. m.	7 p. m. to 1 a. m.	1 a. m. to 7 a. m.
REST EXPERIMENTS.		*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Calories.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
E. O., 9 experiments:											
Minimum	....	2,062	94.5	90.4	83.9	62.8	85.9	.....	.....	.....	.....
Maximum	....	2,452	116.6	124.0	121.8	77.8	102.2	.....	.....	.....	.....
Average	33	2,278	103.7	105.0	101.8	69.2	95.0	27.3	27.7	26.8	18.2
A. W. S., 1 experiment:											
Minimum	....	2,226	111.6	101.6	91.9	62.7	92.8	.....	.....	.....	.....
Maximum	....	2,348	119.8	106.9	94.3	70.4	97.8	.....	.....	.....	.....
Average	3	2,279	114.5	104.5	93.3	67.5	95.0	30.1	27.5	24.6	17.8
J. F. S., 3 experiments:											
Minimum	....	2,065	104.8	93.5	80.0	58.1	86.0	.....	.....	.....	.....
Maximum	....	2,297	119.9	103.6	98.7	64.4	95.7	.....	.....	.....	.....
Average	9	2,136	109.0	98.7	88.2	60.2	89.0	30.6	27.7	24.8	16.9
Average of 13 experiments	45	2,250	105.5	103.7	98.5	67.3	93.8	28.1	27.7	26.3	17.9
WORK EXPERIMENTS.											
E. O., 2 experiments:											
Minimum	....	3,473	195.3	192.8	108.0	68.8	144.7	.....	.....	.....	.....
Maximum	....	4,287	240.5	281.8	128.8	79.6	178.6	.....	.....	.....	.....
Average	8	3,829	212.2	231.5	120.5	74.0	160.0	35.2	36.3	18.9	11.6
J. F. S., 4 experiments:											
Minimum	....	3,253	187.8	185.5	89.9	60.1	135.5	.....	.....	.....	.....
Maximum	....	3,890	239.9	241.3	111.0	70.0	162.1	.....	.....	.....	.....
Average	12	3,540	212.0	216.7	97.2	64.2	147.5	35.9	36.7	16.5	10.9
Average of 6 experiments	20	3,656	212.0	222.5	106.5	68.2	152.3	34.8	36.5	17.5	11.2

From the quantities of heat given off from the body in the different periods of the day, as summarized in Table 150, it will be noted that in the 45 days of the 13 rest experiments with E. O., A. W. S., and J. F. S. the average amounts of heat given off per hour in the 4 successive 6-hour periods from 7 a. m. to 7. a. m. were 105.5, 103.7, 98.5, and 67.3 calories, respectively, the average hourly rate for the whole day being 93.8. The percentages of the whole amount for the day,

given off in the several periods, are 28.1, 27.7, 26.3, and 17.9, respectively.

The average hourly rate for the 20 days of the 6 work experiments with E. O. and J. F. S. was 152.3 calories. The rates for the different periods, beginning with 7 a. m., were 212, 222.5, 106.5, and 68.2 calories, respectively. The corresponding percentages are 34.8, 36.5, 17.5, and 11.2.

It thus appears that in the two day periods in which the subjects were engaged in active muscular exercise for 8 hours the quantity of heat given off was more than twice as much as in the corresponding periods of the rest experiments. In the first night period the amount per hour in the work experiments was not greatly in excess of that in the rest experiments (106.5 as compared with 98.5 calories). In the second night period the quantities were nearly the same (68.2 in the work experiments and 67.3 calories in the rest experiments).

The uniformity in the amounts of heat given off during the second night period calls for special notice. In the rest experiments with E. O., covering 33 days, the range is from 62.8 to 77.8 and the average 69.2 calories per hour. In the experiment with A. W. S., covering 3 days, the range per hour is from 62.7 to 70.4 and the average 67.5 calories. In the 12 days of the work experiments with E. O. the amounts are a little larger than in the rest experiments with the same subject, ranging from 68.8 to 79.6 and averaging 74 calories per hour. That the elimination of heat during this period is larger in the work than in the rest experiments is perhaps explained by the fact that while the subject was decidedly tired at night, and supposed that he slept more soundly than in the rest experiments, he moved more, and to the observers outside the chamber he appeared more restless. In the work experiments with J. F. S. also the amounts during this period are slightly larger than in the rest experiments, ranging from 60.1 to 70 and averaging 64.2 calories per hour. It is noticeable that the rate in the second night period is smaller with J. F. S. than with E. O., the ratio of the former to the latter being about the same in both work and rest experiments.

From the results obtained in the second night periods in these experiments it would seem that from 65 to 70 calories per hour might be not far from representing an average elimination of heat by a healthy, active man in the time of minimum bodily activity.

Relation between elimination of heat and of carbon dioxid.—The rates of elimination of heat and of carbon dioxid in the different periods are nearly parallel, as will be seen by comparing the figures of Tables 147 and 150. Both these values in the two day periods of the work experiments are largely in excess of the similar values in the same periods of the rest experiments. The values for both these factors in the second night periods of the same experiments, which was one of quiet sleep, were small and noticeably uniform.

INCOME AND OUTGO OF ENERGY.

Perhaps the most interesting results of these experiments, both because of their novelty and because of their bearing upon the metabolism and the conservation of energy in the living organism, are those which compare the amounts of potential energy in the materials actually oxidized in the body with the amounts of kinetic energy given off from the body, either as heat alone in the rest experiments or as heat and external muscular work in the work experiments. In the rest experiments there was no considerable amount of external muscular work. The little that was done would naturally be converted into heat—as, for instance, in the impact of the foot upon the floor in stepping, or of the body upon the chair or bed in sitting or lying down. The heat thus imparted to the floor, chair, or bed would naturally find its way to the absorbers, and would thus be carried out with the heat given off as such by the body. Roughly speaking, we may say that all the potential energy made kinetic in the body by the oxidation of food and body material left the body as heat. This is shown by the agreement of the amount of heat given off from the body with the heat of oxidation of the material oxidized in the body. These data are summarized in Table 151.

TABLE 151.—*Comparison of income and outgo of energy in 19 experiments covering 65 experimental days—Amounts per day.*

Subjects and kinds of experiments.	Number of experimental days.	Net income (potential energy of material oxidized in body).	Net outgo (kinetic energy given off from body).	Difference (in terms of net income).	
REST EXPERIMENTS.					
Experiments with E. O.:					
Experiment in which the net outgo falls farthest below the net income (No. 5); average for the whole experiment	4	*Calories.* 2,482	*Calories.* 2,379	*Calories.* −103	*Per cent.* −4.1
Experiment in which the net outgo is farthest above the net income (No. 14); average for the whole experiment	4	2,131	2,193	+ 62	+2.9
Average for 9 experiments	33	2,288	2,278	− 10	− .4
Experiments with A. W. S.: Average for 1 experiment	3	2,304	2,279	− 25	−1.1
Experiments with J. F. S.: Average for 3 experiments	9	2,118	2,136	+ 18	+ .8
Experiments with E. O., A. W. S., and J. F. S.: Average for 13 experiments	45	2,255	2,250	− 5	− .2
WORK EXPERIMENTS.					
Experiments with E. O.: Average for 2 experiments	8	3,865	3,829	− 36	− .9
Experiments with J. F. S.: Average for 4 experiments	12	3,539	3,540	+ 1	0
Experiments with E. O. and J. F. S.: Average for 6 experiments	20	3,669	3,656	− 13	− .4
Rest and work experiments: Average for 19 experiments	65	2,690	2,682	− 8	− .3

The figures for income and outgo of energy require a word of explanation. A distinction is here made between the total[a] income, which is represented by the potential energy of the food, and the net[a] income, which is the energy of the material actually oxidized in the body. This energy of net income is represented by the available energy of the nutrients of the food (i. e., potential energy of total food less that of the urine and feces) minus the potential energy of the material gained or plus that of material lost by the body when the latter is not in nitrogen and carbon equilibrium. The total energy of outgo would be the kinetic energy given off from the body in heat and external muscular work plus the potential energy of the unoxidized materials in the urine and the feces. The net energy of outgo consists of the heat given off and the external muscular work done. The balance of income and outgo is best shown by the net rather than the total quantities. These may be seen in the table given above (Table 151). The averages for the groups of experiments are for the number of days covered by the whole group—i. e., they are not averages for individual experiments.

It is to be remembered that the figures for net income of energy represent the heat of combustion of the material actually oxidized. This material consists mainly of the available portion of the food of which the amount and heat of combustion are found by direct determination. To its heat of combustion is added that of the material lost, or from it is subtracted that of the material gained by the body. The amounts of material gained or lost are determined from the gain or loss of nitrogen and carbon, and their heats of combustion are calculated by the use of factors based upon direct determinations of the heats of combustion of similar substances. The figures for net outgo are the results of direct experimental measurement. In other words, the net income of energy is mainly and the net outgo entirely the result of direct determinations.

A common usage is followed in applying the term "potential energy" to the energy latent in the food and body material oxidized. Whether chemical energy would or would not be a more correct expression no attempt is here made to decide. Ordinary usage is also followed in expressing potential energy in terms of heat—i. e., as calories—thus employing a unit of kinetic energy for the measure. This discrepancy is unavoidable, since we have neither the means for measuring potential energy as such, nor a unit for expressing such measurements if they were made. The use of heat of oxidation for the measure is especially appropriate here, since the energy is liberated mainly by oxidation and appears chiefly or entirely as heat.

[a]The terms "total" and "net" here applied to income and outgo of material and energy are used for present convenience, and may in future reports be replaced by more satisfactory expressions.

The conservation of energy in the body. — If the law of the conservation of energy obtains in the living organism, the net income and the net outgo of energy should be the same. In such physiological experimenting, however, it would be hardly fair to expect the figures for the two to agree for each day of a given experiment or for each experiment as a whole, even if the measurements with the respiration and bomb calorimeters are exact. There may be errors in the estimates of the amounts and heats of combustion of the materials actually oxidized. Variations due to irregularities of the physiological processes of the body are unavoidable and may materially affect the results. For instance, the calculations assume that the quantities of material in the alimentary canal and of carbohydrates in the body as a whole are the same at the end as at the beginning of each day or experiment, whereas they may differ considerably, and the differences would materially affect the results. But it might be hoped that, if the methods are correct, these errors would tend to counterbalance one another in a series of experiments, and that, in the average of a sufficiently large number, the errors would thus be eliminated, so that the income and outgo would be very nearly the same.

Exactly this is the case in the data here reported. The variations for individual days, and even those for the individual experiments, as shown in the detailed tables in this and the previous bulletins, are not inconsiderable, but in the average of all the experiments the agreement is very close. Thus, in the 33 days of the 9 rest experiments with E. O., according to the figures for the individual days the net outgo varies from 165 calories below to 194 calories above the net income. Expressed in percentages of net income, the range here is from −6.5 to +9.1 per cent. Both these extremes occurred on the first days of the respective experiments. In general, the results for the first day of an experiment are found to be less satisfactory than those for the succeeding days. Considering each experiment as a whole, and comparing the averages of the several experiments one with another, the range of variation is less. Here the net outgo varies from 103 calories below to 62 calories above the net outgo per day. Expressed in percentages of net income, the range is from −4.1 to +2.9 per cent. But in the average for the 9 experiments the figures for the net income and outgo are practically the same, being 2,288 and 2,278 calories, respectively. In the average of the 2 days of the rest experiment with A. W. S. there is a disparity of 1.1 per cent, and in the average of the 9 days of the 3 rest experiments with J. F. S. the difference is 0.9 per cent. Taking the 45 days of the 13 rest experiments together, the average income is 2,255 and the average outgo 2,250 calories; the difference is 0.2 per cent. In the average of the 8 days of the 2 work experiments with E. O. the net income and outgo are 3,865 and 3,829 calories, respectively, the difference being

0.9 per cent, and in the average of the 12 days of the 4 work experiments with J. F. S. the net income and outgo are 3,547 and 3,540 calories, or a difference of 0.2 per cent. Taking into account the 6 work experiments with E. O. and J. F. S., the net income is 0.5 per cent larger than the net outgo. The averages for the 65 days of the 19 experiments are: Income, 2,691; outgo, 2,682 calories. The difference, 0.3 per cent, is far within the limits of experimental error and physiological uncertainty.

In experiments of this kind, which represent only the work of a period during which experience with new apparatus and methods is being accumulated, individual discrepancies such as those above recorded seem no larger than might naturally be expected. The agreement of the average results is much closer than was hoped for, and we regard it as by no means certain that future averages will show so exact a balance.

At the same time it is to be noted that when, to the results of the 19 experiments here summarized, those of the 11 others above referred to as published elsewhere are added, the agreement is almost absolute. The 30 experiments covered, all told, 93 days. The average daily income was 2,719 calories and the outgo 2,716 calories. It thus appears that, with increase in the number of experiments, the differences due to unavoidable errors more and more nearly counterbalance one another.

The general subject of metabolism of energy in the living organism will be more profitably discussed when data not yet published are available. Meanwhile it is safe to say that the results thus far obtained fall very little short of definite demonstration of the action of the law of the conservation of energy in the living organism.

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